The official publication of the Association of Physical Plant Administrators of Universities and Colleges

Facilities Manager

Volume 3 Number 2 Summer 1987

Capital Needs in Higher Education

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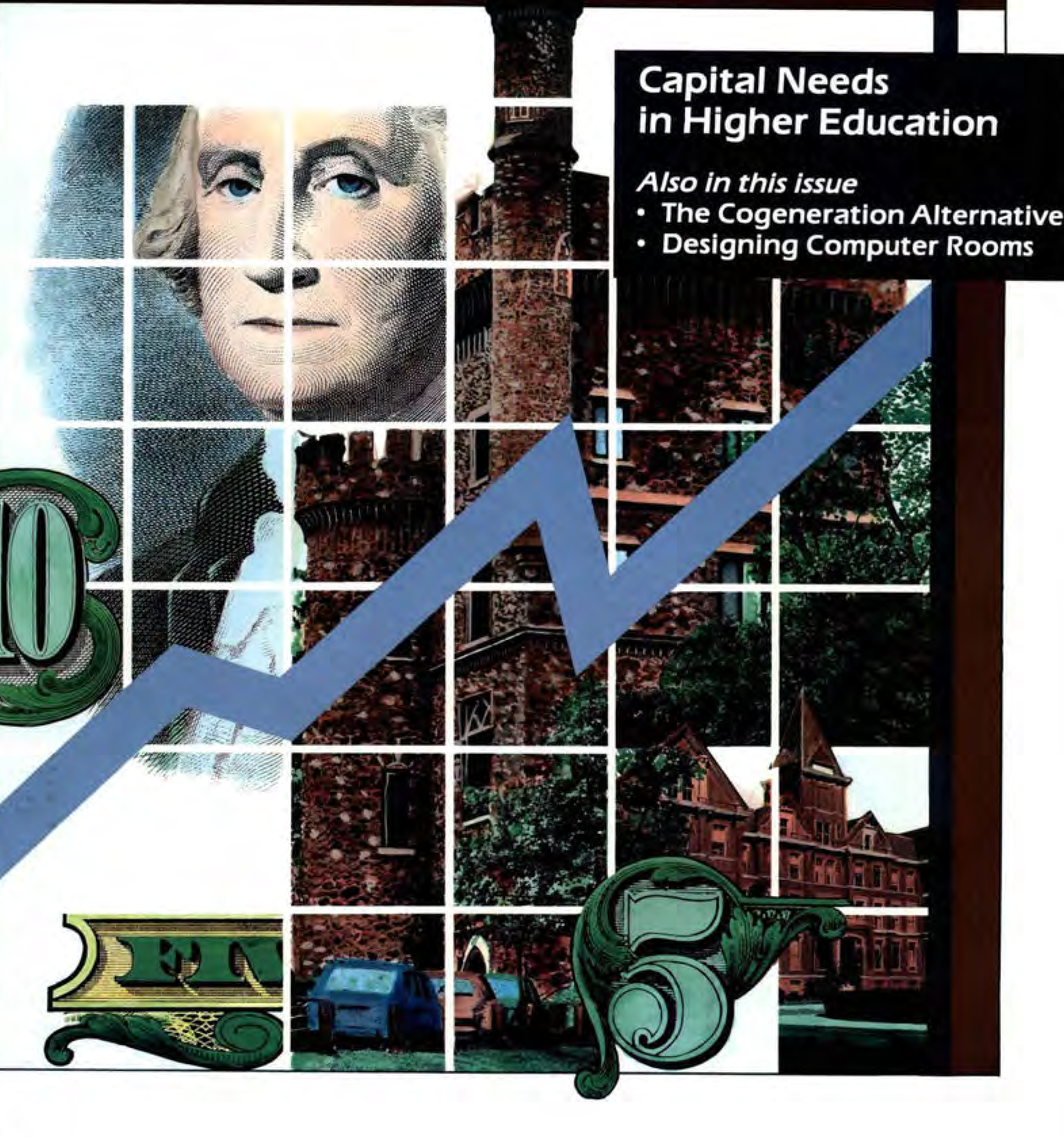
- The Cogeneration Alternative
- Designing Computer Rooms



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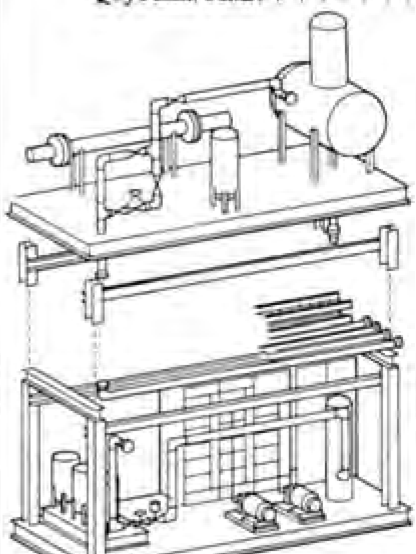
Features



Departments

Cover designed by Ann Saunders

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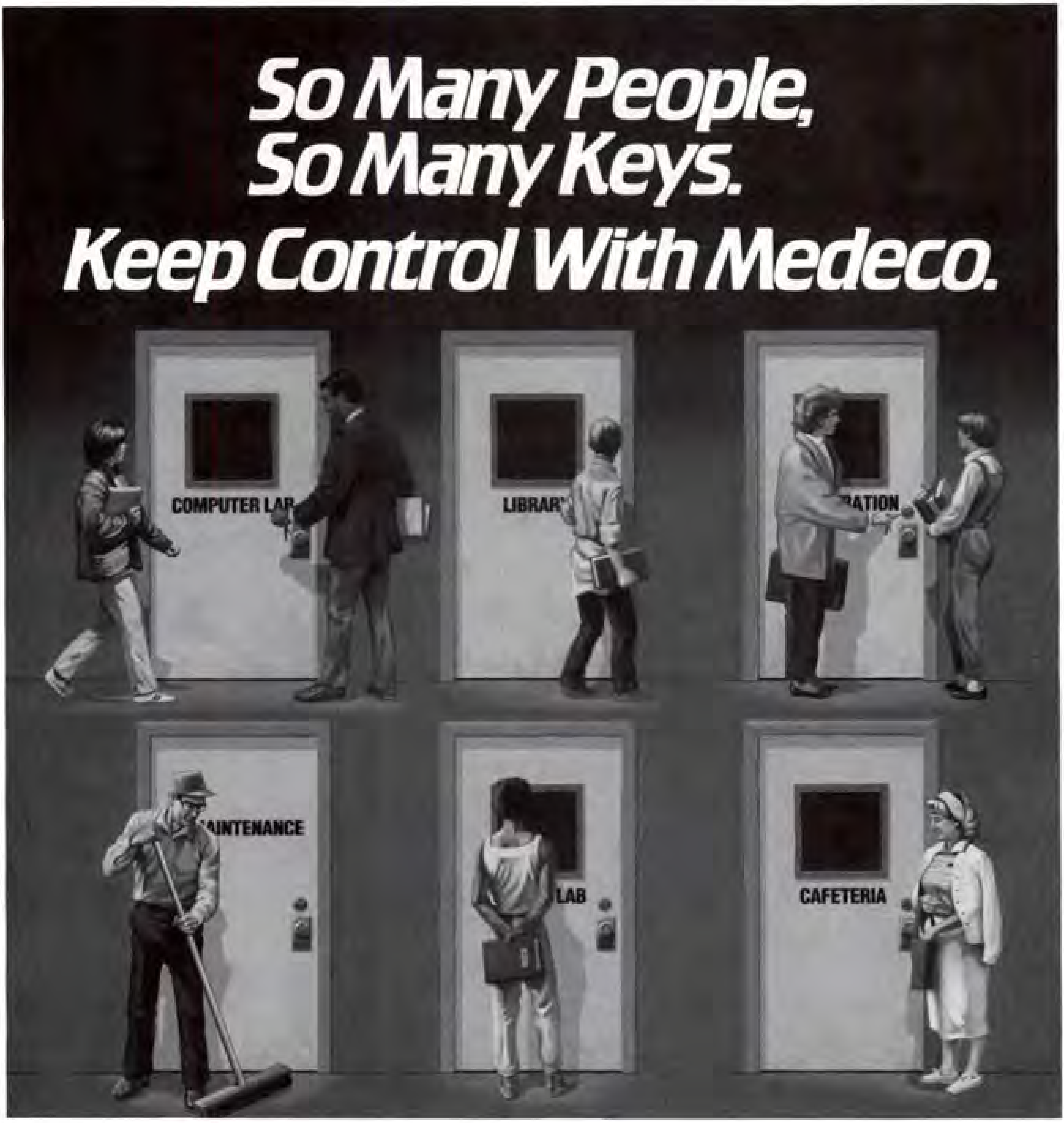

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Perspective

Rayburn V. Lavigne

The Facilities Manager of the 1990s

The fiscal future of most colleges and universities will be even tighter than today. Public universities are already seeing the effect—deferral of salary increases, no operating budget increases, and minimal capital funds. Private institutions are more dependent upon tuition and fees and will have it easier than their public counterparts; however, they will have to be cognizant of the possible negative effects of continued tuition increases in excess of inflation. At what point will price affect demand?

In a nutshell, money will be tighter, and you know the first ones they turn to when things get tight! Most importantly, what will this mean to those of us involved with managing and operating facilities?

It will mean greater accountability. We will have to justify requests and expenditures even more than today. Competition for resources on campuses will be keener than ever. We must continue to find better ways of presenting our case or we will face an even greater crisis than in the mid-1970s.

It will mean greater pressure on operating resources, human resources, equipment, and operating dollars. It is usually easier to tell a facilities manager to cut expenses rather than a music department chair with tenured faculty—not only easier, but frequently the only course short of dissolution of the entire program or department. We will be asked to accomplish the same (usually defined as more) with less.

It will mean more pressure on deferring capital renewal or replacement. It is easier to postpone replacement of a heating system rather than cut the English department budget, at least until it fails in February (or if you're in the South, a cooling system that fails in July).

As colleges and universities, we have a financial accounting system that currently does not reflect true costs. As nonprofit entities we ignore depreciation as there is no tax advantage. But in doing so, we ignore the fact that depreciation is not just a tax issue, it's a real cost. Things wear out, and we should be providing for funding future renewal and replacement of equipment and facilties.

The expansionist period of the 1960s is about to catch up with us. Many of our "new" facilities and systems are twenty years old, about the useful life of most systems even with good preventive maintenance, given the energy and technical advances of the last twenty years. This, combined with tighter resources ahead, makes our task even more difficult.

Many of us are not prepared for this two-edged sword. It's a little like my friend who just bought two new cars because he received an inheritance. He's going to have a major surprise in five years when he has to buy two more at the then current rates. That is what's coming up for many of my collegues—too much coming due at the same time that budgets are already under pressure. Difficult choices lie ahead for all of us.

What type of physical plant professional will be needed in the next decade? What skills and attributes will he or she need? The successful facilities manager will be one who is:

- A flexible, non-stressed individual who must bend, but not break, under the pressure to do more with less.
- A computer literate manager. Whether we like it or not, computer applications are here to stay and, believe me, they will pay dividends. Computers can help us as resources grow thin. If you haven't yet learned, then learn. If you have, then learn more. The applications and payoff are enormous.
- A manager who can understand budgeting and accounting principles and can discuss/present them to others.
- A manager who is a generalist. Individuals who have only one area of expertise will not be effective. The "handyman" of the future refers to managers, not tradespeople.
- A code, regulatory, and legislative expert. Whether we like it or not, more and more of our jobs relate to externally applied, and enforced, rules and regulations.
- A labor relations expert and negotiator. Union or not, relations with our employees will become even more important, especially if budgets get tighter.
- An expert on environmental issues, such as asbestos, chemicals, and hazardous waste. This will become the major issue of the next decade.
- An expert in energy conservation. Don't let the current situation fool you. I don't know of one expert today who isn't forecasting higher energy prices. In any event, I can assure you that prices will be increasing just at the wrong time, in the late-1980s and early-1990s. As other resources become strained due to enrollment pressure, our energy costs will go up at the same time—a double whammy.
- A risk management and insurance professional. As litigation continues to escalate, the pressure for safer facilities and working conditions will be intense.
- A lobbyist, both within the institution and without. You won't be able to sit back and feel that your actions will speak for themselves; you will have to toot your own horn. No one else will do it for you, because they will be too busy with their own horns.
- Above all, as a leader you must have self confidence, integrity, and loyalty. You must find solutions involving what we refer to up north as Yankee Ingenuity. You'd better recognize the snake oil salesman from the miracle potion vendor, because there will be plenty of the former and few, if any, of the latter. There will be easy decisions to make but difficult to carry out. Remember, a leader leads by example, not by title or position.

You probably think that I just described a future college or university president. Wrong. I have described the attributes and skills needed to provide the professional management of our facilities in the coming years.

However, I have not described an individual. The physical plant professional will be an important and vital part of a team, the university or college team. One player does not a team make; it takes an entire team effort to win. You will be a critical part of the team necessary to take higher education into the twenty-first century.

How do you improve yourself to become a key player? Be open to ideas, be flexible, and above all, continue to learn and gather knowledge. The Institute for Facilities Management is a classic example.

Those of you who attend the Institute are attempting to learn and to become even better professionals. Keep it up and encourage your colleagues and peers to attend. Our efforts will eventually pay off.

To those who take the time and effort to become better professionals, my message is simple. Continue to learn and gain the knowledge and expertise to help us all through the next decade. ■

Rayburn Lavigne is assistant vice president at the University of Vermont, Burlington, Vermont. These comments are taken from his keynote address given at APPA's August 1986 Institute for Facilities Management.

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Capital Needs in Higher Education

by Dr. Harvey H. Kaiser

Several signs illustrate the dramatically increasing demands for funding higher education physical plant needs. More and more institutions are announcing major capital campaigns with significant components for plant, in addition to endowments and unrestricted gifts to augment annual operating budgets. The number of institutions routinely announcing campaigns in the hundreds of millions of dollars fails anymore to raise the eyebrows of fundraising colleagues. The challenge has become one of who can be the more audacious in reaching the twenty-first century with the largest campaign goal.

In addition to campus-based initiatives, capital needs for funding from the state houses are entering the scene. The deterioration of higher education's physical plants has awakened elected representatives to the perilous conditions on campuses in both the public and private sectors. Deferral of maintenance, relatively unnoticed until a decade ago, has now begun to prompt action. Individual campuses have surveyed needs and acquired funds through either internal sources or gifts and grants to reduce deferred maintenance. The number of enlightened state legislatures that have either responded to well-presented cases of needs or demanded specific data to justify special budget appropriation is also heartening. But much more funding is required to reduce accumulated plant deterioration funding requirements.

In the past twenty years federal investment in university research plant has declined in real terms by 95 percent,

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according to Erich Bloch, director of the National Science Foundation (NSF). A 1980 study of scientific instrumentation needs of research universities, prepared by the Association of American Universities for NSF, highlighted the dire conditions of campus facilities. Comparisons of university instrumentation laboratories to commercial laboratories revealed that the median age of university equipment in 1980 was twice that of the commercial laboratories in the computer and physical sciences. Engineering reported that 24 percent was obsolete and only 16 percent was "state-of-the-art." The decline in federal funding and lack of increased institutional support led to NSF's conclusion that many research facilities were in need of renovation or replacement.

Decay in physical plant and obsolescence in research facilities and equipment are also drawing the attention of the White House and Congress. In 1985 Representative Don Fuqua (then-Chairman of the House Committee on Science and Technology) introduced the University Research Facilities Revitalization Act of 1985 (H.R. 2823). The bill proposed a $10 billion expenditure over ten years on a 50/50 federal and nonfederal matching basis. Although unsuccessful, similar bills before Congress have developed more promising prospects of passage. Limited to repair, renovation, and replacement of laboratories and other research facilities, H.R. 1905 proposes $250 million for the next ten years. The potential contribution to meeting part of higher education's needs will offset overall capital requirements. These are the first major legislative proposals to address capital needs in many years. A similar response came when the White House Science Council on the Health of U.S. Colleges and Universities Report, A Renewed Partnership (1986), called for increased federal support to the higher education scientific enterprise. The Council concluded independently of the Fuqua initiative the same level of $10 billion required in expenditures for research facilities and equipment over the next ten years, along with encouraging greater industrial cooperation in university research activities.

Through intensive lobbying with state legislatures, public and private institutions have gained access to public funding under the rubric of economic development. The theory at work is that investing in the strengths of academic programs, particularly in science and technology, can foster synergy through academic, industry, and government cooperation. Recently announced long-term, no-interest loans to Columbia, Cornell, and Syracuse universities of approximately $100 million for science and technology centers are examples of state support furthering economic development and meeting campus capital needs.

A corollary of assessing renewal and replacement needs is the portrayal of the big picture: a comprehensive overview of campus plant needs folding

together deferred maintenance with programmatic requirements and enhancement of faculty and student support services. Thus, we have the emergence of strategic facilities planning tying academic planning and student life facility requirements into plans to eliminate plant deterioration. The comprehensive approach now being undertaken by many campuses is producing capital campaigns and more vigorous lobbying for public policy to provide funding for campus capital needs.

Physical Plant Expenditures and Assets

The annual expenditures for operating, maintaining, and adding to plant summarizes the levels of resources dedicated by higher education to its plant assets. How much is expended on operations and maintenance has a direct effect on the conditions of campus facilities; the amounts spent on plant additions represent capitalized investments to replace obsolete facilities, meet new program requirements, and enhance the quality of campus life. An analysis of the past decisions allocating current and plant funds offers some insights into future capital needs.

Current fund education and general expenditures for operation and maintenance of plant include all expenditures for services and maintenance related to grounds and facilities. The National Association of College and University Business Officers (NACUBO) defines this as costs for physical plant administration, building maintenance, custodial services, utilities, landscape and grounds maintenance, and major repairs and renovations. The last category often creates confusion by including work more appropriately classified as that for capitalized renewal and replacement. A difficulty arises from inconsistent accounting practices in differentiating between current and plant fund expenditures for deferred maintenance.

In reviewing plant operations and maintenance expenditures for the past decade, one might expect increased proportions of total expenditures to compensate for several factors: increasing enrollments causing additional wear and tear on facilities; higher required levels of maintenance for more technologically sophisticated buildings; drastically increased utility costs; and inflationary effects on maintenance costs for personnel, materials, and services exceeding rises in the Consumer Price Index. The accumulation of plant improvement costs for the older campus buildings—as well as the large amount of plant added to meet increasing enrollments more than fifteen years ago and now reaching an age of increasing maintenance costs—contributes to demands for additional plant operations and maintenance.

Despite these demands, the portion of operations and maintenance funding has remained almost near-level from fiscal year 1975 to 1984 *(see Table 1)*. Fluctuations have been less than one percent, ranging from ten to eleven percent of total education and general expenditures for operations and maintenance. The tentative conclusion is that unless additional funding is made under categories of renewals and replacement or plant additions, the unfunded needs of deferred maintenance will continue to grow.

By examining book value of plant additions for buildings and equipment, we can obtain an indication of levels of plant fund expenditures for renewals and replacements and new construction. In the period from 1970 to 1983, book value for buildings more than doubled. Converting the annual additions to 1983-84 constant dollars using the Boeckh Construction Index presents a more accurate picture of trends in annual plant additions. From $7.8 billion in 1970-71, plant additions declined to $3.7 billion in 1983-84, a decrease of 57 percent *(see Table 2)*. In constant dollars per student, expenditures for new construction dropped from a peak of $577 in 1967 to $120 per student in 1983.

An over-building of higher education in the 1960s is now being counteracted by a more cautious position due to stable or declining enrollments. However, the drastic decline in plant additions for building, combined with near-level operations and maintenance expenditures, suggests an increase in deferred maintenance and a pent-up demand for upgradings, renovations, and new construction. Demands for adding facilities for specific needs, such as in research or improving outdated housing built in the 1950s and 1960s, will place heavy resource burdens on some campuses.

Book value increases from 1970 to 1983 also show a steady increase for new equipment and replacements, rising from $800 million to $2.7 billion. In constant dollars, additions for equipment were relatively level until 1980. As a result of increased federal aid for higher education equipment purchases, additions to equipment value have risen dramatically *(see Table 3)*. With trends in all prices up sharply, future equipment purchases will buy less than in the past. And the continued purchase of more costly equipment compounds the problem.

Determining Capital Needs

Now to the heart of the issue: how much is needed to meet the capital requirements for higher education's physical plant? Seeking the answer is an elusive quest. The frustrating response is that in the national aggregate there is no reliable measure. By assessing historic data and anecdotal information, some general estimates of the funding required to correct existing campus conditions can be prepared. However, the aspirations of programmatic requests or enhancements to the quality of campus life nationally remain unquantified.

Ideally, the summary of individual campus resource needs for buildings, grounds, utilities, and equipment would provide aggregates for system, state, or national comparisons. Assembled

Table 1

Plant Operation and Maintenance
1975-1984

Fiscal Year	Total Educat'l & Gen Expenditures (000's)	Plant Oper & Maint Expenditures (000's)	% E&G
1975	$27,547,620	$2,786,768	10.12%
1976	30,598,685	3,082,959	10.07%
1977	33,151,681	3,436,705	10.4%
1978	36,256,604	3,795,043	10.5%
1979	39,833,116	4,178,574	10.5%
1980	44,542,843	4,700,070	10.55%
1981	50,073,805	5,350,310	10.68%
1982	54,848,752	5,979,281	10.9%
1983	60,785,097	6,391,596	10.515%
1984	65,860,992	6,729,825	10.2%

Table 2
Trends in Additions to Plant Value-Buildings
Fiscal Years 1970-1983 (000's)

Academic Year	Building Value	Boeckh Constr. Index 1983-84 = 100	Annual Increase Bldg. Value	Constant Dollar Increase
1969-70	$31,865,179			
1970-71	35,042,590	36.58	$3,177,411	$8,686,197
1971-72	38,131,339	39.58	3,088,749	7,803,936
1972-73	40,808,481	42.07	2,677,142	6,363,107
1973-74	43,701,491	44.93	2,983,010	6,438,378
1974-75	46,453,642	50.15	2,752,151	5,488,259
1975-76	49,349,224	54.01	2,895,582	5,361,453
1976-77	52,384,393	58.60	3,035,169	5,179,643
1977-78	55,188,603	62.82	2,804,210	4,464,087
1978-79	57,563,005	67.15	2,374,402	3,535,890
1979-80	60,847,097	72.73	3,284,092	4,515,765
1980-81	64,158,017	79.78	3,310,920	4,150,095
1981-82	67,794,877	87.68	3,636,860	4,147,995
1982-83	71,519,718	94.43	3,724,841	3,944,607
1983-84	75,220,765	100.00	3,701,047	3,701,047

Source: National Center for Education Statistics

Table 3
Trends in Additions to Plant Value-Equipment
Fiscal Years 1970-1983

Academic Year	Equipment Value	Equipment Price Index 1983-84 = 100	Annual Increase Bldg. Value	Constant Dollar Increase
1969-70	$7,151,649			
1970-71	7,893,100	73.27	$ 731,451	$1,690,434
1971-72	8,734,866	44.10	841,486	1,908,305
1972-73	9,513,503	45.46	778,917	1,713,300
1973-74	10,412,914	49.01	899,411	1,835,193
1974-75	11,518,536	58.52	1,105,622	1,889,409
1975-76	12,653,847	61.38	1,135,311	1,849,518
1976-77	13,910,107	64.39	1,256,260	1,950,957
1977-78	14,961,131	68.84	1,051,024	1,526,874
1978-79	16,250,737	74.41	1,289,606	1,733,093
1979-80	17,849,119	80.51	1,598,382	1,985,264
1980-81	19,390,097	87.60	1,540,978	1,759,159
1981-82	21,319,297	93.99	1,929,200	2,052,514
1982-83	23,584,042	97.75	2,264,745	2,316,834
1983-84	26,309,602	100.00	2,725,560	2,725,560

Sources: National Center for Education Statistics, Inflation Measures for Schools and Colleges, D. Kent Halstead. U.S. Department of Education 1983.

through uniformly administered instruments for data collection, campus-based surveys of needs would provide clear conclusions for policy guidance. Unfortunately, the lack of universally prepared and collected surveys of needs prevents the compilations necessary for presenting a convincing public policy picture.

The information gap existing at the campus level also prevents reliable inter-campus comparisons of need. Many campuses continue to make capital budget decisions in the traditional manner: high priority programmatic requirements struggle to the surface along with the most pressing renewal or deferred maintenance priorities. Missing is any systematic audit of facility conditions or evaluation process for determining long range priorities for functional replacements or future program needs.

A promising source of capital needs information results from demands of governing boards and state legislators. Unlike a traditional compilation of line item requests for renovations or plant additions presented in annual or biennial budgets, campuses are now engaging in detailed surveys of plant conditions and justifications of facilities before introducing fundraising campaigns or presentations of requests to governing boards or legislators. The results of these mandates have proved gratifying with thoroughness of preparation producing new streams of funding for deferred maintenance and new facilities. Sometimes only funding needs on a partial basis, the initial responses have proven encouraging.

A coherent picture of campus capital needs is aided by defining main categories of need. Major repairs are costs associated with deteriorated conditions due to deferred maintenance, such as roof replacements, interior building finishes, or mechanical, plumbing, or electrical system replacements. Upgrading and renovations are costs associated with modification for functional inadequacies or obsolence due to changing space needs for program use of a facility. New construction includes plant additions for expansion, new programmatic requirements, or enhancement of quality of campus life.

The category of plant additions has the tendency to become a "wish list." Such requests are the hardest to sort out as absolutely necessary capital needs. Unless strong personal presentations are made to move them from the suspect category of frills and amenities into essential requirements, plant addition requests remain suspect. The handicap of guiding national policy on higher education capital needs through the lack of comprehensive data in existing conditions and anticipated needs prevents a clear set of conclusions of resource requirements. This frustration can be overcome partially by reviewing available data and anecdotal information on existing conditions. Relationships between plant replacement values and estimated costs for correcting existing conditions provide ranges of need for overall capital requirements.

The last national survey of the condition of all higher education facilities was prepared by the National Center for Education Statistics (now named the Center for Education Statistics) in fall 1974. It was then reported that approximately 20 percent of campus facilities was in an unsatisfactory condition. Recent statewide and campus surveys of facility conditions show that ratio to be consistent. The following examples support that conclusion; a selection of available information and the projected renewal and replacement estimates are enlightening.

North Carolina. A 1982 facilities and inventory study of public and private institutions with 72 million gross square feet reported 17.4 percent of space in an unsatisfactory condition. The estimated cost of restoring space to a satisfactory condition was $301.6 million.

University of California System. A detailed survey in 1983 of 60 million gross square feet had a capital maintenance backlog of approximately $2 billion at $33.60 per square foot.

Texas. A 1982 survey of twenty-five institutions of the College and University System Coordinating Board, excluding the University of Texas and Texas A&M, evaluated conditions of educational and general facilities ten years and older. Total costs of renewals and replacements for 21.3 million gross square feet of space was estimated at $301 million.

Indiana. A 1983 survey of the Indiana Commission for Higher Education's seventy-eight campuses totaling 33.6 million gross square feet reported 24 percent of the space in unsatisfactory condition. Total replacement value was $3.34 billion.

University of Maryland. In 1985 a report was presented to the Maryland Board of Regents for the eight campuses of the University of Maryland. Critical capital needs were defined for a five year period totaling $555.5 million: $224.1 million to correct deteriorated facility conditions and $331.4 million for new facilities. The 1986 allocation for deferred maintenance was $2.5 million with an estimated annual renewal need of $22.5 million per year.

New York. A 1982 survey of 196 million gross square feet of space reported 20 percent of the space in unsatisfactory condition.

Similar surveys in Kansas, Iowa, and Arkansas reported approximately 10 to 15 percent of replacement values required renewal or replacment. Two private institutions provide supportive

data on the magnitude of costs for renewal and replacement. Columbia University prepared a detailed survey of conditions in 1984 for 7.11 million gross square feet of space. The estimated capital maintenance backlog was $247 million at $34 per gross square foot. Syracuse University conducted an intensive campaign to eliminate deferred maintenance beginning in 1972 for 7.1 million gross square feet that eventually cost over $170 million. Escalating those costs to 1984 would produce a total similar to Columbia University's projections.

There are two approaches to determining the major repairs and upgrading and renovation components of capital needs. The most thorough approach is the campus-based audit of existing conditions of buildings, grounds, utilities, and equipment. An alternate method is to use life-cycle analyses in lieu of actual amounts comprising the backlog of deferred maintenance. By factoring the age and replacement cost of building components, a renewal and

Table 4
Building Replacement and Book Values
Fiscal Years 1970-1983 (000's)

Academic Year	Book Value: Land	Book Value: Building	Book Value: Equipment	Book Value: Total	Boeckh Constr. Index 1983-84 = 100	Building Replacement Value	Annual Increase Repl. Value	Constant Dollar Increase
1974-75	$4,210,901	$46,453,642	11,518,536	$62,183,079	50.15	$79,340,614		
1975-76	4,345,232	49,349,224	12,653,847	66,348,303	54.01	89,381,799	$10,381,799	$19,222,917
1976-77	4,444,927	52,384,393	13,910,107	70,739,427	58.60	95,969,973	6,247,560	10,661,722
1977-78	4,621,071	55,189,603	14,961,131	74,770,805	62.82	105,159,012	9,189,039	14,628,245
1978-79	4,824,250	57,563,005	16,250,737	78,637,992	67.15	115,038,214	9,879,202	14,711,817
1979-80	5,037,172	60,847,097	17,849,119	83,733,388	72.73	130,417,556	15,379,342	21,147,242
1980-81	5,212,453	64,158,017	19,390,097	88,760,567	79.78	142,979,847	12,562,291	15,746,289
1981-82	5,402,339	67,794,877	21,319,297	94,516,513	87.68	156,991,860	14,012,013	15,981,303
1982-83	5,889,080	71,519,718	23,584,042	100,992,042	94.43	165,038,516	8,038,516	8,521,409
1983-84	6,109,746	75,220,765	26,309,602	107,640,113	100.00	181,550,765	16,512,249	16,512,249

Source: National Center for Education Statistics

replacement allowance can be budgeted to offset facility aging each year. Empirical studies have produced ranges of 1.5 to 3 percent of plant replacement value as appropriate levels of annual funding for renewal and replacement.

Added to annual funding are costs to correct existing deferred maintenance. The 20 percent level of "unsatisfactory conditions" is a reasonable assumption based on the historical data and selected examples. Using this assumption, the 1983-84 total building replacement value of $181 billion *(see Table 4)* would require $36.3 billion to correct deferred maintenance. Adding equipment replacement value brings the total over $200 billion and a deferred $40 billion to $50 billion.

At a modest inflation rate of 3 percent, an annual commitment of between $4 billion and $5 billion is required nationally to eliminate deferred maintenance. In addition, a minimum of 1.5 percent of total replacement value of buildings and equipment requires almost $3 billion a year for facility renewal.

For a campus with $300 million in replacement value for buildings and equipment, this translates into $60 million for deferred maintenance and $4.5 million a year for facility renewal. Again, omitted are the projections of capital additions still fermenting in the campus community. New academic programs or outstanding space needs, innovative research activities, and faculty and student support facilities will wend their way into the capital budget process by the subtleties of campus politics and other pressures.

How much of the $3.7 billion spent on campus plant additions in 1983-84 reported by the NCES was for major repairs, upgrading, renovations, or new construction is unclear. However, the reports of deterioration, aging facilities, and obsolete equipment suggest that unmet capital needs are much higher than the amount spent that year.

An important principle for campus decision makers and higher education policymakers to remember is that a one-time elimination of current renewal and replacement priorities does not solve the problem. As campus facilities continue to deteriorate and become obsolete, an annual allocation for renewal and replacement is necessary to prevent further accumulation of deferred maintenance. Establishing an appropriate level of annual funding in the beginning of a facility program may have to include "catch-up" costs. As needs are reduced to manageable proportions, the operating budget can accommodate priorities as they are identified. The end result is a program that maintains campus facilities in good repair so they are functionally adequate for instruction, research, campus life, and community service. ■

A FOUR-PART SERIES ON ELECTRICAL ISSUES

PART 3
The Cogeneration Alternative: Feasibility and Factors

by Mohammad H. Qayoumi, Ph.D.

According to the Public Utility Regulatory Policies Act (PURPA), a qualifying cogeneration facility is one which produces less than 80 megawatts of power where no more than 50 percent of the investment is made by the public utility. If the facility is using wind, solar, water, biomass, waste, or other renewable energy sources, no other criterion has to be met. One of the following criteria must also be met if the facility is using coal, gas, or oil:

- The thermal useful energy of a topping cycle must be 5 percent or greater of the total energy output.
- The total system efficiency must be at least 45 percent; however, if the useful thermal energy output is greater than 15 percent, then the total efficiency must be at least 42.5 percent.

It is important to keep in mind that PURPA defines efficiency as

$$\frac{\textit{power output} + (\textit{useful heat}/2)}{\textit{fuel input (lower heating value)}}$$

which has no scientific significance. For a bottoming cycle the efficiency of the fuel input to useful power output must be 45 percent.

The finalized Federal Energy Regulatory Commission (FERC) regulation resulted in a sharp increase in the number of qualifying facilities. For instance, in the first three years the qualifying status jumped annually from 450 MW to 3800 MW, and by 1985 it was more than ten times the 1980 total. By conservative estimate, the anticipated market size will be 25,000 MW by 1995.

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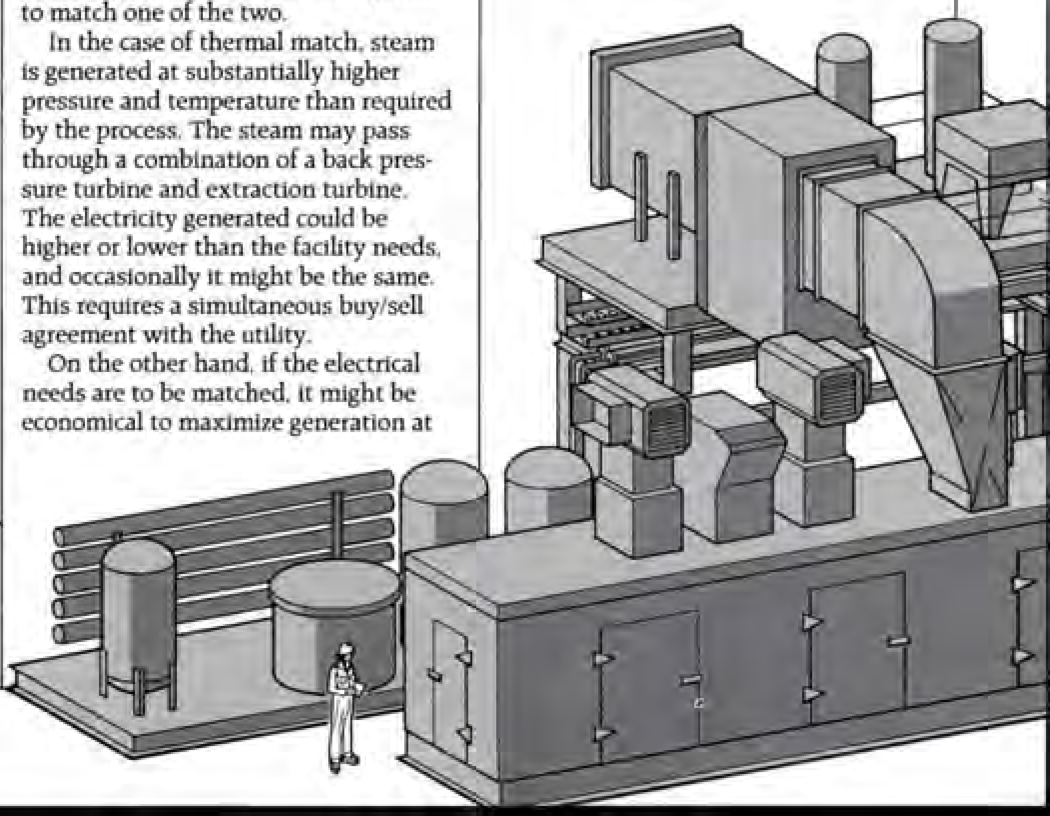
Basic Design Schemes and Technologies

Ideally, the thermal and electrical needs of a cogeneration system should always match, but in reality they do not often follow the same demand patterns. If this were the case, there would not be any need to buy or sell power to the utility. Therefore, it becomes important to design the system to match one of the two.

In the case of thermal match, steam is generated at substantially higher pressure and temperature than required by the process. The steam may pass through a combination of a back pressure turbine and extraction turbine. The electricity generated could be higher or lower than the facility needs, and occasionally it might be the same. This requires a simultaneous buy/sell agreement with the utility.

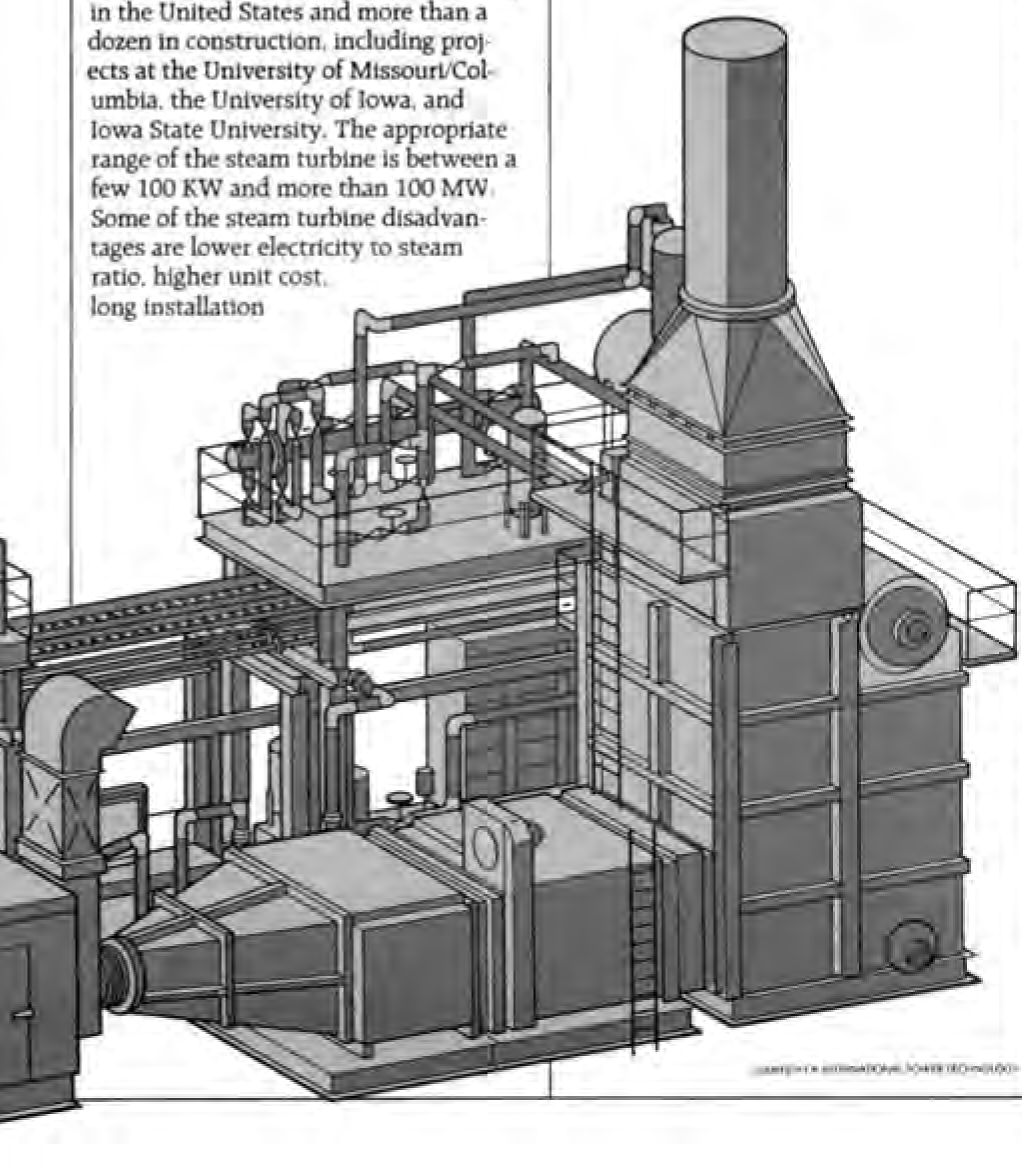
On the other hand, if the electrical needs are to be matched, it might be economical to maximize generation at one level. Here the necessary agreement with the utility might be for purchase, sale, or a buy/sell agreement depending on the size of the cogeneration unit and the electric demand variation of the facility.

There are basically three different technologies used to power the cogeneration prime mover: steam turbine, gas turbine, and reciprocating engines. Steam turbines have high overall efficiency and reliability and can utilize a wide range of fuel. One of the best uses for the steam turbine is to burn solid fuel such as solid waste, coal, tree bark, and wood chips. Fluidized bed boilers



offer greater fuel flexibility especially in burning high sulphur coals and other solid fuels and waste with sufficient sulphur dioxide (SO_x) and nitrogen oxides (NO_x) control without any additional flue gas cleanup system. Bubbling bed technology is a relatively older technology that can achieve efficiencies between 70 and 90 percent. Circulating fluidized bed (CFB) boilers have only been commercially available since 1985 and can achieve efficiencies of 97 percent with fly ash reinjection. There are about half a dozen CFB boilers operating in the United States and more than a dozen in construction, including projects at the University of Missouri/Columbia, the University of Iowa, and Iowa State University. The appropriate range of the steam turbine is between a few 100 KW and more than 100 MW. Some of the steam turbine disadvantages are lower electricity to steam ratio, higher unit cost, long installation time, longer startup time, and larger space requirement.

Gas turbine cogeneration systems have a number of attractive advantages, namely high power-to-heat ratio, low capital operating and maintenance costs, shorter construction time, lower required square footage, and high overall thermal efficiency. The main disadvantage is the limited fuel range and relatively shorter service life. That is why large gas turbine cogeneration systems are not economically attractive in areas where the electrical utility generation is coal based. Gas is more expensive than solid fuels for the same quantity of thermal energy.



The reciprocating cogeneration system has the highest electricity-to-steam ratio. This is due to the thermodynamic difference between reciprocating cycle, where almost two-thirds of the waste heat is rejected in the form of low temperature energy, and gas turbine, where waste heat is in the form of high temperature exhaust gas. The other advantages over the gas turbine are higher part load efficiency and lower sensitivity to ambient air temperature. The disadvantages of reciprocating cycle, however, are higher capital and maintenance costs and possible environmental problems. Reciprocating systems are most suitable for small commercial applications up to a few hundred kilowatts.

Based on the order of generating electricity and thermal energy, cogeneration is divided into topping and bottoming cycles. With a topping cycle electric power is generated first at higher temperatures, and the rejected heat is used to produce thermal energy. In a bottoming cycle process heat is produced first, and the rejected heat is used to generate electricity. Bottoming cycles have low efficiency and fewer applications than topping cycles. They are usually used in cases where waste heat is free, but even in those cases they might be competing with waste heat recovery systems such as feed water heaters or process heat exchangers. In some instances a cogeneration system can have both a topping and a bottoming cycle.

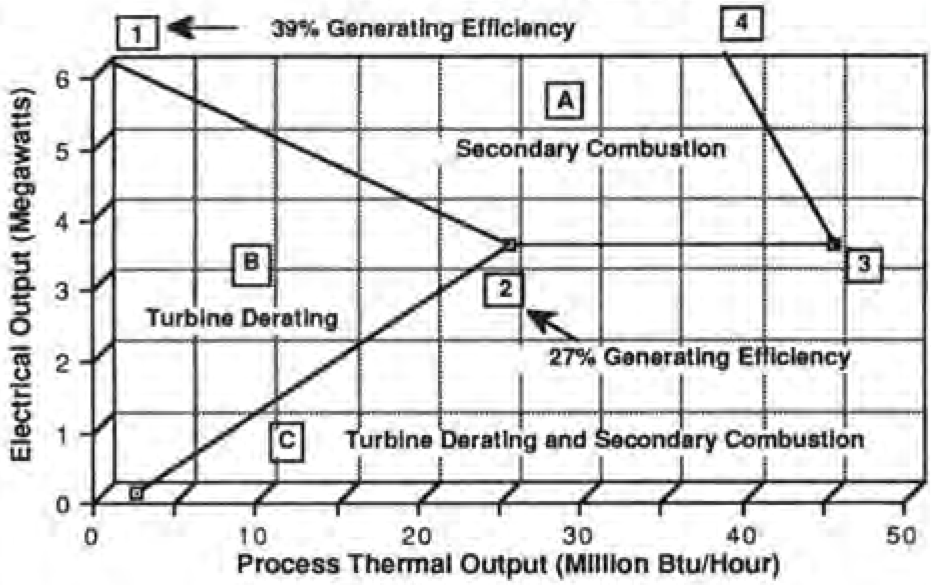
Cheng Cycle

The economic factors for running a cogeneration system vary drastically when a more complicated electric rate structure with demand charges, standby charges, energy charges, and time of day electric load is optimized with thermal load. One way of overcoming this drawback of the traditional cogeneration system is to use the Cheng Cycle, which has the ability to produce virtually infinite combinations of electricity and steam output. A Cheng Cycle consists of a gas turbine with a matched waste heat recovery steam generator (HRSG). Steam is generated at any temperature and various pressures. When the steam required by the process exceeds the amount produced by recovering gas turbine exhaust gas energy, more fuel can be burned in the duct work between the gas turbine and HRSG. Such a process has a high thermal efficiency for converting supplementary fuel fired for thermal energy.

The operating regime of the Cheng Cycle is shown in *Figure 1*. Normally the system will operate along Line 1, 2, or 3 or within Region A. Line 1-2 designates electric and thermal output for rated turbines inlet temperature and varying level of steam injection. At Point 2, no steam is injected so the electric and thermal output is equal to the gas turbine. At Point 1, all thermal energy produced from waste heat is injected back to the turbine and a generating efficiency of 39 percent is achieved; while at Point 2, the generating efficiency is 27 percent with a cogeneration efficiency of 86 percent. In Region A the addition of supplemental heat in HRSG allows any combination of thermal and electrical output. Region B represents lower turbine firing temperatures; while in Region C, the electrical output is reduced by turbine derating and no steam injection.

There are three basic modes of operation for a Cheng Cycle. Under normal mode the system works along Line 1-2-3 where thermal demand is met and the electric output floats. During time intervals where the electric rate is highest, the system operates along Line 1-4 to maximize electrical

Figure 1 Cheng Cycle Operating Regime



output. The steam load might or might not be met. On the other hand, when the utility buy back rate is low or the utility interconnection is down, the system will match the thermal and electric need of the facility. The operating point in this case can be anywhere in Regions A, B, or C.

Another advantage of a Cheng Cycle is the low level of NO_x emission. Conventional gas turbines have NO_x emission rates of thirty to forty parts per million (PPM) while Cheng Cycle can achieve an average emission rate of below 25 PPM. Cheng Cycle has been developed by Dr. Dah Yu Cheng of International Power Technology (IPT). There have been a number of Cheng Cycle systems installed in the past three years, including San Jose State University and Sunkist Growers.

Electrical Considerations

Prior to PURPA, electric utilities controlled the electric power distribution grid entirely, and under normal circumstances would not allow any customer to tie in a dispersed generation site to the power grid. This had resulted in a safe and reliable operation of the electric power systems and provided a high quality of service. Therefore, PURPA started a new chapter in the way the utilites have to deal with dispersed generation sites that not only produce small quantities of power relative to what utilities generate, but also are operated by organizations that are not in the business of producing electricity.

The concern of utilities in allowing interconnections of the cogeneration is to make certain that these systems will not jeopardize the safety of utility personnel and the quality of service. During normal conditions the utility wants to know if the power produced by the cogeneration site will be entirely used by the customer or how much of the power will be sold to the utility. Moreover, it wants to make sure that the harmonic voltage and frequency tolerances of the dispersed generation site meet the grid tolerances. During emergency conditions, the utility wants to make sure that network faults are detected by the cogeneration device and are isolated from the grid, and then how service will be restored. Moreover, it wants to know that safety

Figure 2 Schematic of Cheng Cycle

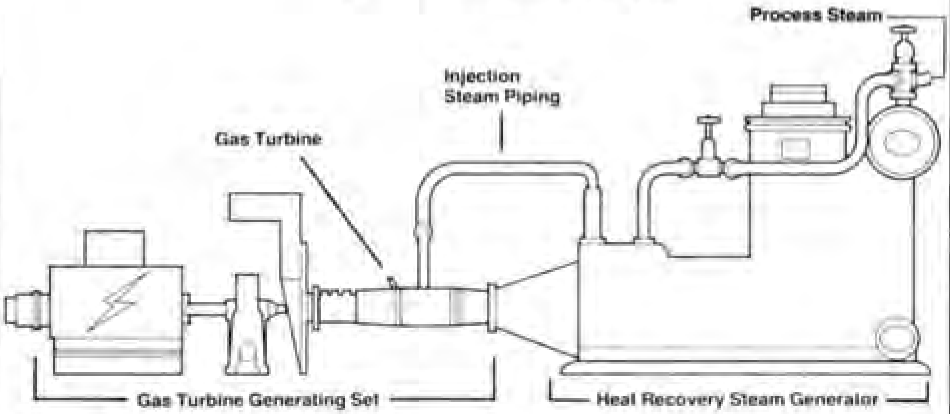
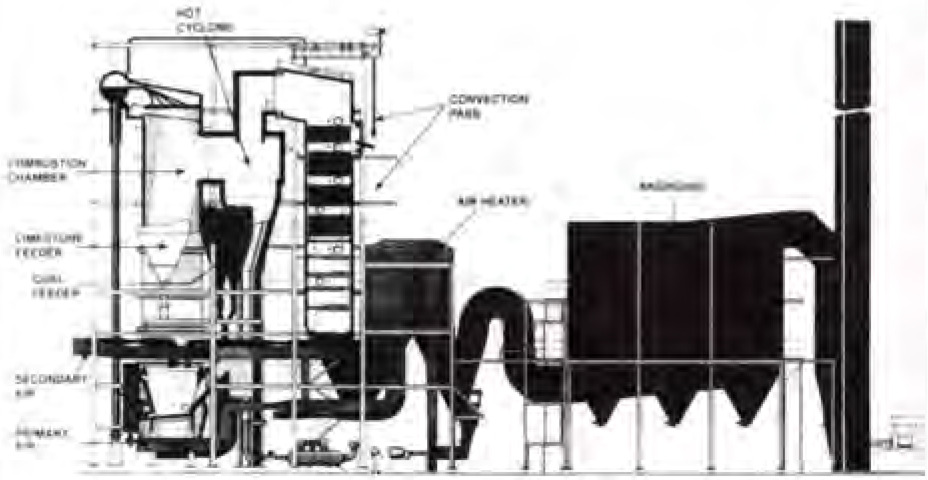


Figure 3 Schematic of a Circulating Fluidized Bed Boiler



of utility personnel is not put in jeopardy by these units.

The utility electric distribution network is radial, which means that to isolate an area requires opening and locking a main circuit breaker. With cogeneration, the power network is no longer radial but a loop distribution. Therefore, it is crucial for the utility to record the location of all cogeneration units and have access to a manual load-break disconnect at all times. The interconnection requirements of a cogeneration system depend on interconnection voltage, transformer configuration, protection scheme, and on-site load and generation capacity.

There are two types of electric generators, synchronous and induction. A synchronous generator is one type commonly known for AC systems. It produces electricity at 60 Hz and can be connected to the grid by a synchronizing gear. The induction generator produces power at variable frequencies, and an inverter converts the power to synchronized 60 Hz before it is connected to the network. Induction generators are used for small units of up to a few megawatts. Larger units are invariably synchronous generators. Each of the two requires a different protection scheme.

Electrical Protection for Cogeneration

In a utility distribution network the overcurrent equipment is arranged in a series of overlapping zones to clear a fault on a prearranged sequence of primary devices and backups. This is achieved with coordination of time-current characteristics of fuses, circuit breaker reclosers, sectionalizers, and relays from a substation. In a faulted condition the available current drops as one moves from the substation to the customer site because of increase in systems impedance. Therefore, coordination is relatively simple. With cogeneration interconnection, a bi-directional power flow on the distribution system can continue to energize a part of the network separated from the utility system reference source. Moreover, a cogeneration site can contribute additional overcurrent during faults that may cause the protection services to operate prematurely.

This high current level from the cogeneration site is over and above the available fault current from the utility. This will shorten the average melting time of the line fuses. On a 15 kv system a small synchronous cogeneration unit of a few megawatts can reduce the fuse melting time by better than 30 percent. For an induction generator the reduction in melting time is about one-third of the synchronous generator.

Another problem is with utilities' auto-reclosures. The faults that occur with an overhead transmission system are usually momentary faults and are self-clearing. The auto-reclosure closes the circuit a few cycles after the circuit was interrupted. In this way the customer downtime for such momentary faults will be minimal. With cogeneration in the system, although the utility breaker has interrupted the circuit, the fault is fed by this unit and does not get a chance to clear. Therefore, when the circuit is closed by the auto-reclosure, the fault has not cleared and this means longer downtime for customers. The presence of cogeneration changes the available fault and the system coordination for in-house systems as well as the utility grid.

Utilities are also concerned with the problem of islanding. Islanding means that the cogeneration site is operating independently of the reference voltage and frequency of the utility power grid and is no longer in synchronism with it. Utility personnel might assume that by opening the linebreaker the circuit is de-energized. The generator voltage and frequency variations might cause damage to the load, which can be costly. If the utility breaker is closed without synchronizing the cogeneration unit, serious damage can also be incurred to the generator and breaker.

The harmonics generation from cogeneration sources must also be studied. Since for economic reasons the magnetic core of in-house generators is not made of the high quality materials from which the utility grade units are made, the core non-linearities of cogeneration units will produce harmonics that cause problems with computers and other sensitive electronic equipment.

Minimum Protection Requirements

If there is an internal electrical fault with the cogeneration unit, the available fault from the utility grid will cause major damage. Therefore, the electrical protection needs of a cogeneration system should not be taken lightly. The required protection depends on unit size, generator type, in-house load, and interconnection voltage. For small units where power is totally used in-house, overcurrent, over/under voltage, and current directional relays are required. If power will also go to the utility grid, then over/under frequency and negative sequence relays will be needed in addition to the first two relays. For larger units the following additional protection relays are recommended:

- Differential protection
- Loss and excitation
- Overspeed
- Motoring protection
- Stator and rotor protection
- Overheating

For induction units, surge overspeed and internal shorts protection are recommended. Keep in mind that the protection levels suggested in the earlier paragraphs are a mere guideline. Local utility requirements and the site conditions must be taken into account. To restate, pre-cogeneration facilities were only receivers of power; now they are a partner in the power grid with the utility. It is the responsibility of both sides to ensure that the reliability and safety standards of the network are not compromised by the presence of cogeneration systems.

PURPA Impacts

During the past seven years cogeneration has jumped from 4 percent to 7 percent of the nation's electric supply; the Department of Energy predicts it will approach 15 percent by the year 2000. Cogeneration has been an outlet for dodging electric rate increases; but in the meantime, electric utilities in many parts of the country have successfully formulated barriers for cogeneration by adopting tariffs that penalize cogeneration systems.

For instance, special deals are offered to keep from dropping off the system, or a denial of standby power is threatened if the project is owned and operated by third parties. The standby power became an especially important issue after the ruling that denied Alcon, Inc. (Puerto Rico) standby power because FERC found Alcon to be neither the owner nor the operator. In some instances, for long term contract requirements utilities have established requirements they themselves do not have to meet.

Another problem that has faced cogeneration sites is the lack of clearly defined regulations regarding wheeling of power. Wheeling is the selling of electricity to a non-adjacent customer using the utility's power grid or power network.

Although Florida, Indiana, and Texas have required utilities to provide wheeling service to cogenerators, it is still an area of concern. PURPA also has not specifically addressed sale of power by cogenerates to nonutility entities. Public Utility Commissions (PUC) has encouraged the development of standard contracts that leave little or no room to negotiate for avoided cost methodologies and rates. Nonetheless, California, Connecticut, Florida, and Virginia have done so, and a few other states are in the process. In California cogeneration projects have faced two other hurdles—one is a milestone procedure where certain goals must be met within specific time frames to preserve the right to sell the power contracted to the utility. California has also passed standards to limit NO_x to 42 PPM, which might cause problems for some gas turbines.

During the past five years two other external factors helped the cogeneration marketplace. These were the potential tax benefits offered by investment tax credit (ITC) and depreciation deductions under the accelerated cost recovery system (ACRS): this encouraged many third party financing of projects. But the tax changes of 1986 eliminated ITC and reduced ACRS benefits by immediate tax write-offs. This will sharply reduce cogeneration ventures which had been justified by large tax benefits.

Does this mean that cogeneration projects will no longer be economically feasible? The answer is no. It means that projects that were originally justified with large tax benefits and/or large quantities of power sold to the utilities will cease to be attractive. Most cogeneration projects will now be built solely to meet in-house power requirements. There will therefore be a sharp decline in the number of cogeneration projects with 30 MW or more; in contrast there will be a sharp increase in the small package cogeneration market. According to a study by Frost and Sullivan, there is a five to seven billion dollar market for small packaged cogeneration units under 5 MW between now and the year 2000. International business information companies predict that the cogeneration capacity in the United States will increase from 17,750 MW to 40,000 MW, and about 7000 MW will be from facilities below 5 MW.

The potential market for small packaged systems will be shopping centers, apartment complexes, hotels/motels, supermarkets, laundries, and so forth. The cost range of these systems is between $1300 to $2000 per kilowatt. Thermex Corporation, one manufacturer of small package cogeneration, has marketed a system rated at 6-8 KW electrical with 55,000 BTU/hr of usable heat. This unit is 2.5 x 2.5 x 5 ft. in size, weighs about 680 pounds, runs on natural gas and costs $10,000 to $12,000. The company hopes that this scaled-down model becomes as popular in new homes as air conditioning.

Conclusion

The cogeneration market has moved beyond the original intentions of PURPA. The Industrial Fuel Use Act of 1978 barred utilities from building new gas- and oil-fired generating plants. This resulted in an increase of availability and a reduction in cost of natural gas, which encouraged more cogeneration and small production systems. As the cost of coal- and nuclear-based electricity grew, larger industrial customers left the system, which further added to the utilities' reliance to increase rather than decrease their dependence on natural gas. This problem will be more obvious when gas supplies drop and prices rise, which does not appear to have been the original intent of PURPA and FUA.

Cogeneration has also been responsible for the structural changes that electrical utilities are going through. Utilities have had to examine the deregulation of electric utility transmission systems, diversify into nonregulated subsidiaries, and become a more competitive player in the energy market.

There has also been some new legislation passed at the state level. For instance, cogenerators in California can sell power to adjacent sites. In Connecticut utilities are required to offer thirty-year contracts and provide wheeling to other in-state or out-of-state utilities.

Therefore, it can be concluded that cogeneration has come a long way from where it began. It is here to stay and is going to be a viable option for many institutions.

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[Ed. Note: For more information, see Cogeneration: A Campus Option?, *by Robert L. Goble & Wendy C. Goble. Available at $21 ($15/APPA members) from APPA, 1446 Duke Street, Alexandria, VA 22314-3492. Add $8 shipping/handling; nonmembers must prepay.]*

Design Considerations for Computer Rooms

by A.S. "Migs" Damiani, CPE

The facilities manager is often delegated responsibility for facilities planning, design, construction, and maintenance. Whenever these responsibilities are split and the facility manager is not directly involved with planning, design, and construction, "designing for maintainability" is seldom a major design criteria. No maintenance program devised could overcome the "built-in" costs that are normally associated with deficient design.

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Few facilities are designed with operating and maintenance costs set out as a major design criterion. Doing so, however, will pay for itself many times during the useful life of a building, and usually the initial capital investment is minimal. Operating and maintenance costs can easily add up to more than 700 percent of the building's original cost.

Armed with these facts, one would think that companies and institutions would insist that emphasis be placed on O&M costs, but they often are not. As facility managers we should continually stress to our top management and administration the importance of designing for maintainability.

One of the most expensive pieces of real estate in any building, and one that deserves special attention, is the data center. It is possible to invest as much as $3,000 per square foot in hardware and software in a data center, and the O&M costs are staggering. In relationship to that investment, the cost of a well-designed data center that supports the hardware/software only represents three to five percent of the investment. Deciding not to cut corners on data center design is the secret of a successful data center—one that will be running at all times and would be designed to maximize efficiency, productivity, and expandability with minimal O&M costs.

Few architectural/engineering firms are capable of designing data centers properly. The design of a data center is sophisticated and requires a high degree of specialization. It is imperative that designers of data centers know hardware and be familiar with software applications (after all, that is the critical asset being protected), understand local area networking and telecommunications, and be especially strong in mechanical/electrical engineering design. In selecting an A/E firm, it is recommended that past experience be listed at the top of your selection criteria. Visting A/E offices and jobs they have done should be a rule rather than a guideline.

Most A/E firms require considerable information from their clients regarding their data center requirements. Not unlike a computer, the A/E's output (construction documents) is only as good as the input they receive from the client. At the minimum, the client is responsible for furnishing information regarding space programming, hardware and hardware characteristics (BTU, KWs), operational needs, and cabling configurations.

It has been my experience that most clients are unable to identify fully their scope of services. It is also not uncommon for clients to experience change orders amounting to 25 percent of the initial construction cost due to design deficiencies; much of this could be avoided with proper design.

Pre-planning

Prior to selecting an A/E firm, the institution should plan its needs and formulate, *in writing*, a detailed program of requirements (scope of services) for the consultant's reference. Performance by the A/E is directly dependent on the owner's understanding of the project requirements. At this stage:

- Be as detailed as possible when writing the program requirements. The construction cost estimate and the time allowed for design are based on this program.
- Allow sufficient time for design. The facility, when built, will last longer than anyone on the design team.
- Be prepared to pay reasonable fees that allow the performance of a top-quality job, including the construction support component.
- Determine construction costs with the consultant's help. Generally that estimate becomes part of the contract as a budget objective.
- Try to reduce the program in size and not in quality, if the estimate is higher than the budget. Function and life-cycle considerations such as energy conservation and maintainability should have top priority. Aesthetics should be a secondary issue, subject to economics. Communicate this principle to the consultant at the outset.
- Prepare single-line drawings indicating the desired hardware configuration and those areas that must be physically separated, such as control rooms, print rooms, vaults for tape storage, halon closets, telecommunications areas, and offices.
- Indicate areas to be used for support equipment, offices, conference rooms, storage, employee lounges, and reception areas.
- Prepare an "adjacencies matrix" chart indicating priorities as to what interrelationships exist among various departments and other areas of the building, such as the mail room and loading docks.

Control console in computer room.

Other information you should obtain that could assist you and the consultant during pre-planning includes the following:

- Find out how power is being fed into the site and building and how much capacity exists. Is redundant power available? What has been the power failure history? How clean is the power coming into the building?
- Floor and roof loading.
- Zoning regulations.
- Building plans indicating ceiling heights, corridor widths and heights, elevators (number, size, type, capacity, location), mechanical/electrical, door openings, security, and fire alarm systems.

A properly designed data center should include office areas since programmers and systems analysts are electronically connected to hardware via CRTs and local area networks, which are or should be tied into an uninterruptible power supply (UPS) and diesel generators. In addition, the written scope of services should include the design objectives of providing maximum uptime of equipment, minimizing operation and maintenance costs, value engineering studies of systems and equipment, maximizing flexibility and expandability, and maximizing space utilization.

Design

The design process is an area that deserves special emphasis because it is at this stage that most problems can be solved. Sufficient time should be allowed to create and review plans adequately, to rework design, to minimize change orders associated with errors and omissions, and to research design concepts to ensure that they will work in the field. For the best results in design:

- Work closely with the A/E during the design process. Do "on-board" reviews as much as possible to save time normally lost in design review. A review by maintenance personnel can be useful in assuring proper access to equipment as well as providing adequate storage, maintenance, and custodial space.
- On large projects, do a value engineering review in the preliminary stages.
- Utilize the services of an outside estimator. Accurate information at various design stages helps keep projects within budget.

Data Center Location

Location of the data center significantly affects initial and O&M costs. To minimize costs and to provide the best work flow possible, data centers should be located on the ground or basement floor of a building, close to mail rooms, elevators, and loading docks.

Generally, these areas have better ceiling heights, more above-ceiling plenum space, wider corridors, and minimal floor loading problems. It is important that data centers be closer to incoming power switchgear and adjacent to the outside. This is desirable for UPS rooms, diesel generators, and placement of condenser, chillers, and/or cooling towers. If zoning regulations or layout will not permit use of the outside ground areas for placement of cooling towers, it is still possible to run piping through vertical chases up to the roof or penthouse.

The perimeter of data centers along outside walls should be windowless. If security is a problem, expanded metal can be utilized within drywall systems. Some disadvantages of ground floor locations are water/moisture problems and lengths of local area networking (LANs), particularly if many people scattered throughout a high-rise facility or across a campus have to be connected to hardware within the data center. Moisture/water problems can be solved by sloping the concrete floor to drain and installing moisture detection devices as an early warning system. This assumes that you or the consultant would have tested the soil characteristics, taken borings, and studied water tables on the site.

Hardware Configuration

Prior to any good design of a data center, computer hardware and peripheral equipment should be laid out for its optimum configuration and with expansion in mind. Knowing particular equipment and its environmental needs (such as KW, BTUs, and air circulation) are critical to good layout.

In laying out hardware, give consideration to best space utilization, operational requirements, work flow, personnel movement, length and access to power cables and wiring, and telecommunications interface. You must also decide how tapes will be stored—vault, slab-to-slab room, open storage. Consider migration planning, wire/cable management, and disaster recovery in the process.

All of these considerations affect the design of the data center support equipment, raised floor layout (to ensure access/flexibility of underfloor access), air distribution, and construction sequencing. Detailed coordination is a must for all systems utilized in a data center. And do not forget to satisfy your need for storage within the operations area—for stationary supplies, forms, paper, custodial supplies, etc.

Corridors

Corridors and doorways should be wide enough and high enough to permit easy handling of equipment and supplies. Flooring in corridors should be of vinyl composition tile or other hard, durable, maintenance-free material. Partitions along corridors should incorporate bumpers/wall protection and be covered with durable materials, since materials handling equipment easily damages walls. Recess water fountains and fire extinguishers and be sure to install sufficient convenience outlets for cleaning services. Convenience outlets within the data center should be run back to the building system's electrical panels.

Partitioning/Ceilings/Lighting

To maintain required environmental conditions for temperature, humidity, and fire suppression, a one-hour slab-to-slab perimeter drywall system is generally designed for perimeter walls. In most cases, the drywall is insulated for desired acoustics and sealed with caulking on top and bottom to provide a vapor barrier.

Slab-to-slab partitions are recommended for print rooms to contain equipment emissions with special filtration mounted to the ceiling directly above the equipment. Operational needs often dictate that glass be incorporated with drywall for office areas and all-glass systems be used for separating other areas. Note that many architects use butt-joint glazing, which is expensive to install and replace; if you decide on this system, be sure to use ½"- or ⅝"-thick glass. Value engineering and experience has indicated that glass and mullion systems are nearly equal in appearance, are much less expensive, easier to maintain, more readily available, and easier to replace.

Dropped ceilings within the data center should be backed with foil to create a vapor barrier and incorporate hold-down clips in the event of halon discharge. Lighting fixtures should not have troughs.

Other uses for drywall are for chases, furring out columns and walls, and for built-out columns, which surfaces can be used to recess annunciator panels and bells/horns, fire protection, site monitoring, and UPS monitoring.


Lighting under computer floor for safety and maintenance.

Doors

Doors are subjected to more abuse in data centers than in most other uses. They must be made weather-tight to maintain environmental requirements and sealed to minimize halon leakage in the event of discharge.

Designing for ease of operation and maintenance should be the rule rather than the guideline. Consider installing doors with automatic openers. Solid single or double doors should be fire-rated and have appropriate kickplates and other heavy-duty hardware to prevent marring and damage. Door widths and/or heights should be able to handle access and egress of equipment without having to remove doors and door frames.

Acoustics

The hard surfaces of walls and flooring required for maintainability often reflect and accentuate the noise generated by hardware and peripheral equipment, thus making the environment non-conducive for productivity. Sound-soak wall panels/coverings are generally used to provide quieter working environments. Carpet tiles are sometimes used for raised flooring, but static electricity and other disadvantages are associated with the use of floor carpeting in data centers.

When the budget permits, it is possible to make data centers more aesthetically pleasant. Use of wall coverings, special ceilings, special lighting, butt-joint glass, and special paints such as polymix can make space more pleasant.

Raised Flooring

There are many types of raised flooring available on the market—wood-core, steel, combinations of wood/steel, concrete filled—in a variety of laminates and carpeted surfaces. Carpeted flooring, although it has good acoustical/aesthetic advantages, should not be used for a working data center. Laminates are durable and easy to maintain.

Raised flooring considerations should include a recommended height of 18" (depending on the type of mechanical system utilized and the amount of wiring/cabling required), floor loading for static and rolling loads, fire ratings, and accessibility requirements.

Other important tips on flooring include:

- Make sure that a reputable installer is available—in all cases, proper installation is critical.
- Require experienced installers to use lasers in leveling floors. All concrete subfloors are not level and other means of leveling raised floors are not sufficient.
- Ensure that your specifications contain a provision for spare tiles with and without cutouts and spare perforated panels for flexibility and maintenance.
- Subfloors should be sealed, then cleaned thoroughly prior to operation.
- Provide lighting underneath the floor for safety, ease of maintenance, and inspection.
- Slope the concrete subfloor to drain in order to minimize water/moisture problems (if the data center is located on the ground level).

Mechanical Systems

In the modern data center, supplemental state-of-the-art air conditioning units are used. These work in conjunction with a variety of mechanical systems that are air cooled, water cooled, chilled water, glycol, or glycool.

It is important to understand the impact that various systems in data centers have on other systems. For example, water cooled and chilled water systems require substantial piping under the raised floor, which in many cases dictates the minimum height of raised floors and vertical chases for piping to the roof or outside the building.

If chilled water systems are utilized, your life-cycle cost analysis should include an investigation of waterside economizers, which often are cost effective considerations. The manner and route under the raised floor should be such that it does not interfere with the hardware cabling, wiring, air distribution, and access.

Spare pumps and redundancy in systems should be considered and, whenever possible, heat rejected by the data center should be re-used to heat the building during winter months.

Mechanical equipment should be isolated from the raised floor and placed on floor stands. Be careful not to obstruct proper air distribution under the floor. I cannot emphasize enough the importance of knowing the computer hardware to be installed.

Most data centers are designed around hardware, and they should be. However, attention should be paid to

Computer center disk drive farm.

the people who will work in the data center; BOCA mechanical codes require minimal ventilation. It is insufficient to introduce fresh air into a data center directly from the outside—conditioned air from the building system should be utilized. Ideally, fresh air should be introduced directly into the environmental control units.

Fire Suppression

Halon fire suppression systems are usually required for data centers and support areas. In some cases it is good to back up the halon system with a dry-type sprinkler system using local annunciators and tied into the building system. When halon is used, dropped ceiling systems should be clipped down. Halon is best provided with a central system with storage tanks housed in a halon closet.

Data centers are generally provided with smoke detection systems in the plenum above the ceiling, in the room itself, and below the raised floor for early warning. The detectors are designed in a cross zone pattern. Before the halon can be discharged, two detectors must be activated. Hand-held fire extinguishers should be located in the room to extinguish small fires.

Another problem that requires early warning is moisture detection. Detectors located under the floor with central monitors are available and should be utilized.

Electrical Systems

Most data centers include separate support areas for switchgear, isolation transformers, uninterruptible power sources, and diesel generators. Some equipment—such as power distribution units, power conditioning systems, EPO buttons, site monitoring and annunciation panels, lighting, wiring, and cables—are located within the room itself.

Switchgear. It is sometimes possible to use high voltage switchgear that will conserve energy and reduce costs. Switchgear with automatic transfer switches is often custom-designed for data centers. Whenever "off-the-shelf" equipment is recommended, take care that construction documents are specific and submittals by the contractor are limited only to the manufacturers/model numbers called for in the specifications. Electrical switchgear should always be mounted on 4"-6" housekeeping pads for safety and designed for anticipated expandability.

Power Distribution Units. Power distribution modules allow more flexible and better distribution of power cabling within the data center and allows certain monitoring to the user. Cabling should be ordered separately so as not to affect equipment delivery. In addition, order only when you can identify exact power cabling needs, such as cable length, type, and receptacle requirements.

Power and Signal Grounding. Power grounding is done for electrical safety only and is not used for enhancing the operation of equipment in a data center. Signal grounding, on the other hand, is primarily concerned with noise-free operation of electronic system and reliability considerations. Signal grounding must be done in a compatible way that does not undo the safety aspects of the installation.

Uninterruptible Power Supply (UPS)/Diesel Generators. Both UPS for ten to twenty minute protection and diesel generators, which can provide days of protection, increase the reliability of the data center. When any amount of downtime is unacceptable, both systems are recommended.

One important consideration relative to UPS is that the battery room is ventilated directly to the outside because of possibility of hydrogen gas emitted from batteries. The room requires environmental controls, generally necessitating a supplemental air conditioner. Fire suppression is desirable and an eye wash/shower station (away from the batteries) is required.

Noise is also a problem; UPS areas should be separate but near the data center. Partitioning should be designed to minimize noise transmission to the surrounding environment. Battery rooms should contain a drain and neutralization tank on a waterproof, acid-resistant floor in the event of acid spillage. You may choose to include a locker with appropriate safety equipment—goggles, rubber gloves, aprons—available for maintenance personnel. Floor loading for batteries should be approximately 300 pounds per square foot.

Diesel generators are generally located near an outside wall or in separate buildings between 100 and 300 feet of the data center. Sufficient space should be set aside for expansion. Because diesel generators are costly, noisy, and emit pollutants, your design should ensure that these are addressed and that sufficient fuel oil storage is located nearby underground, with access for truck delivery. You should require the contractor to top off the fuel oil reserve prior to turning over the project.

Wiring/Cabling. During design and construction it is important to develop a wiring/cabling management plan. Literally miles of wires are used in a data center and between the data center and personnel requiring access to the hardware. Good records and drawings indicating where wires are placed initially or added later, and identification of the wiring itself (on both ends), is a must in today's well-designed data center.

Security

Security systems compatible with building security should be investigated and utilized to prevent access by unauthorized individuals. Commonly used are cardkey systems, electronically operated cipher locks, and automatic door openers. Expanded metal is a good way to protect perimeters of data centers.

Vaults are often used to protect vital tapes and other sensitive material and require special construction. To maximize storage capacity, "space-saver" type systems are used for storage of tape both inside a vault or in an open environment.

Special Cleaning

Initial cleaning of a data center is extremely important. The same air is being used over and over to maintain the proper environment. Have the cleaning done by an experienced professional in data center cleaning.

Central Monitoring

Centralize all panels in an area that will be supervised on a 24-hour basis. Built-out columns provide a good place for centralizing inexpensively.

Migration Planning

Plan your move while you are in the design phase. It will assist in providing certain construction sequencing that should be communicated to all bidders and leave nothing to the imagination. Good migration planning will minimize the amount of downtime normally experienced during data center moves and provide a smooth transition.

Post-Construction

You will gain, in the long run, by keeping track of the project after completion. To follow up on the project:

- Request that the designers provide a written report based on the first year's operation and use of the facility. Use the feedback to make corrections and as input for future projects.
- Encourage maintenance personnel to provide reports as to how everything is working. ■

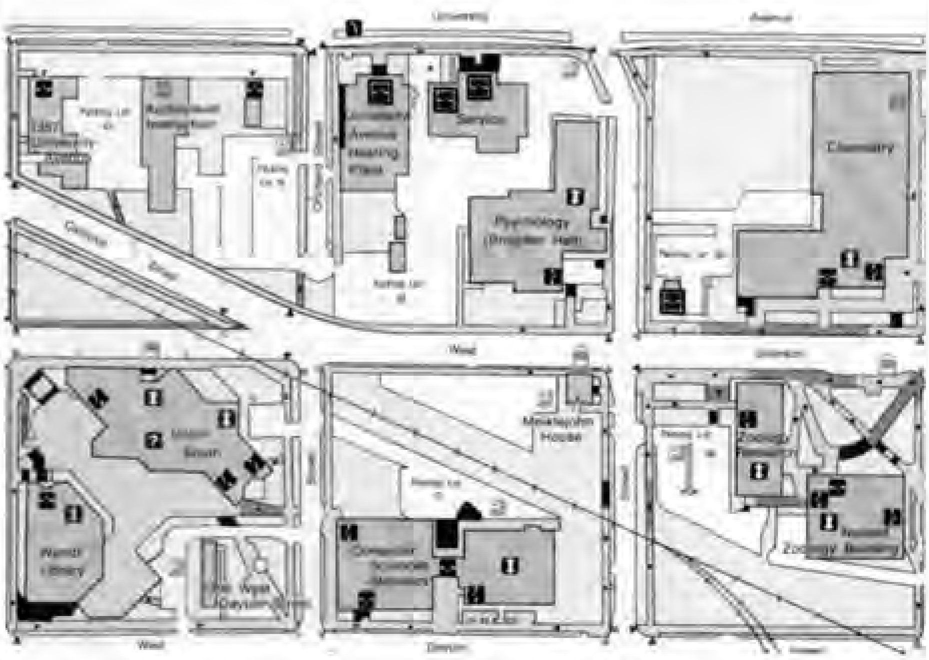
Management Resources

J. Roger Kurtz

If your department has developed an innovative program or utilized unique resources, please share them with us. Send a short description to Management Resources, FACILITIES MANAGER, 1446 Duke Street, Alexandria, VA 22314-3492.

Accessibility Maps

The University of Wisconsin/Madison received some publicity recently for its color-coded accessibility maps for the campus. *DVR News*, a publication of the Division of Vocational Rehabilitation of the Wisconsin Department of Health and Social Services, highlighted the system in its December 1986 issue. The school's maps delineate the rise and fall of the land through the use of colors. Also included are symbol guides to bus stops, parking for people with disabilities, telephones reachable from wheelchairs, curb cuts, and grade-level building entrances. Volume-controlled telephones and telecommunication devices for the deaf (TDDs) are also noted. Visually impaired persons may also be able to use the maps once they are linked to a campus-wide computer network with voice synthesizers, the next step of the process.



Faculty Cooperation

The physical plant department at Indiana University/Bloomington is trying to promote the idea of having each academic department designate a person to serve as a liaison between the department and the physical plant. Or, in cases where several departments are housed in one building, a building representative is the goal. "We need to have a direct link with all of the departments, and designating one individual in the building can be an effective way," says Bruce Williams, physical plant operations manager. "By using this individual, departments can shorten response time and provide a more effective means to solve problems as they arise." Building representatives handle anything having to do with maintenance, upgrades, and renovation. It speeds things up, and keeps everyone happier.

Retrofit and Save

Public schools in Columbus, Ohio have joined together in a shared savings energy efficiency program that has resulted in significant savings—more than $1.1 million in energy bills last year alone. The shared savings program was used in retrofitting twenty of Columbus' school buildings and is part of a larger energy management program that has been in effect for three years.

Body Language

Men and women in this culture speak different body languages, something managers should be aware of in the mixed sex workplace. So claims Janet Mills, a professional development specialist. Mills classifies nonverbal behavior into submissive, or typically feminine, actions and dominant, or typically masculine, actions. Men use larger, more forceful gestures than women, smile less frequently than women, and square their shoulders more. When a woman bends to pick up an object from the floor she keeps her knees together, her back straight, her arms close to her body, and approaches the object from the side; a man would squat, bending his knees, keeping his back flexible, his arms extending from his body, approaching the object from the front. Women close their eyelids when shifting their vision to another direction; men keep their eyes open. Professionals need to be aware of these and other differences, claims Mills, in order to be able to transcend sex roles.

Employee Fitness

West Virginia University's physical plant is shaping up—with a special emphasis in 1987 on employee health. "Just for the Health of It" is an optional four-part health program developed by the physical plant for its employees. High priority on an injury-free workplace is one aspect of the program, with a plaque rotating to the department that has gone the longest without injuries. A program to help individuals reach their ideal weight features an initial weigh-in and a monthly prize for the most weight lost or gained towards a person's goal. Stress control seminars use films, discussions, and demonstrations in small groups. And everyone who gets a physical exam receives a certificate and recognition in the department newsletter.

Saving Some Cool(ing) Cash

Providing enough air conditioning for a university in South Texas is no easy task, but the cooling plant at Pan American University in Edinburg, Texas is doing it and saving money at the same time—a cool $200,000 last year alone in gas and electrical bills. "Utilities—electricity, gas, and water—are major expenses," says Plant Engineer Hormoz Jafarzadeh. "We've implemented an energy conservation plan to keep them as low as possible. Last year, we had increased demand and still managed to save." Two central computer systems are essential to the plant, efficiently regulating the activity at what Jafarzadeh calls the largest cooling plant in South Texas. Air conditioning the school is a big job: Pan American spends $90,000 a year just for the water it uses, and about 66,000 gallons of chilled water are circulated throught the buildings on campus every hour. The recent addition of new cooling towers and water chillers gives the plant the capacity to produce 72 million BTUs of cooling power per hour. With its computerized system, the school anticipates continued savings. And they certainly have incentive—that $200,000 from last year contributed to staff and faculty salary increases this year! ■

The Bookshelf

The Changing Face of Organized Labor

Unions in Transition: Entering the Second Century, ed. by Seymour Martin Lipset. San Francisco: ICS Press. 1986. 506 pp. $29.95/hardcover: $12.95/softcover.

Unions in Transition is a collection of new articles written by economic analysts, management executives, and labor leaders. The topics covered include a history of the American labor movement, comparison with other countries' experiences, economic impact of unions, public sector unionism, public opinion of labor unions, and current labor relations as viewed by both management and labor. The book handles this broad subject well for two reasons: the unparalleled expertise of the authors, and the presentation of both sides of each issues. *Unions in Transition* is provocative and forces the reader to rethink current opinions. The book is a timely review of the American labor movement at a time when its power is seen by most to be waning. Every manager will find useful observations and information regarding organized labor, regardless if his or her employees are currently organized.

Typically, the authors discuss past and current conditions and their significance in anticipation of the future role of organized labor in the United States. The historical data presented is sufficient that the reader need not be a student of labor history to profit from the book. While the majority of the contributing authors are scholars noted for their research of labor issues, this is not a dry or difficult textbook. Of particular value is the section of authors' notes which provides an excellent resource for further reading on a given issue. The index is comprehensive.

The following questions are representative of issues covered in the book.

- Is the American labor movement in a permanent, irreversible tailspin? The AFL-CIO's Committee on the Evolution of Work has studied the current situation and issued a series of corrective steps for labor to improve its standing. The book offers a look at some of these recommendations.
- Should organized labor be deregulated, similar to the process recently affecting many industries in the United States? This would include the repeal of laws and rulings that give preferential treatment to unions in organizing drives, strike activities, and public accountability.
- What impact do unions have on the economy? Does the lower turnover rate of an organized work force offset the accompanying higher wages, expanded benefits, and restrictive work rules? The book has a lively debate on this issue.
- Traditionally, the American public has rated confidence in unions very low and confidence in union leaders even lower. Given this fact, why do the majority of people still feel unions are a necessary and positive force in society? Another interesting point is the view that unions have too much influence and the worker has too little. Lipset's articles are an excellent review of public opinion polls.

- How do the top people in management and labor see the current labor relations climate? Can we expect less confrontational relations in the future? Even though the management of the AFL-CIO has developed a strategy for the 1990s, will the local chapters adhere to it?
- Has the United States entered a period of labor surplus? In his chapter, Lane Kirkland cites high unemployment as the primary problem facing organized labor.
- Can the AFL-CIO reconcile the varied and often opposing agendas of its public and private sector unions?
- Should we expect a movement demanding a more democratic framework within unions due to a more educated membership that sees participation as requisite to support?

The only section of the book that may not be relevant is the comparison of the United States with other countries. While these articles are well written and offer a good historical view, the topic is not very instructive for a typical operations manager.

Overall, *Unions in Transition: Entering the Second Century* is an informative collection of articles that express the current thinking of the premier analysts of organized labor in the United States.

Unions in Transition is available from ICS Press, Institute for Contemporary Studies, 785 Market Street, Suite 750, San Francisco, CA 94103; 415/543-6213.

—Terry Conry
Director of Building Maintenance
Ohio University
Athens, Ohio

Making Recreation Accessible

The International Directory of Recreation-Oriented Assistive Device Sources, ed. by John A. Nesbitt. Marina del Rey, California: Lifeboat Press, 1986. 259 pp. $49.95, softcover.

This publication describes many assistive devices available to the disabled for their participation in a variety of sports and recreation activities. The first of its three sections simply lists the different devices described in the publication. Each device is listed by name, disability, and function. The entries are cross referenced, enabling the reader to find the device and its source quickly in the second section of the book, "Assistive Devices and Sources."

In this second section the authors outline under each recreational category the specific problems that the disabled person encounters and the solutions offered by the various assistive devices as well as brief descriptions of how they work. The names and addresses of the manufacturers are also provided. Most of the items have illustrations accompanying the written description. The only area that this publication does not address is the approximate cost of each device.

The third section of the book, "Facilities Modification," outlines renovations that can be made to buildings and facilities so that they will be accessible to the disabled. Using the combination of the second and third sections will allow the reader to both modify the physical environment as well as provide assistive devices for individuals so that they may participate in the recreational activities that take place in that environment. Although this section covers specific areas of accessibility, the reader should be cautioned that many states and the federal government now have specific requirements that are addressed in more detail by such standards as ANSI 117.1.

This publication is good as a single source for discovering many devices that can be helpful and important in making your recreation-oriented facilities and programs accessible to people with disabilities ranging from mobility to sight or hearing impairments.

The International Directory of Recreation-Oriented Assistive Device Sources is available from Lifeboat Press, P.O. Box 11782, Marina del Rey, CA 90259.

—Stephen R. Cotler
Architect
Latham, New York

Something New in Time Management

Excellence Through Time Management, by Richard I. Winwood, with Hyrum W. Smith. Salt Lake City, Utah: The Franklin Institute, Inc. 1985. 135 pp. $11.95, hardcover.

Whew. Thought I'd never find the time to write this review! Friends, that comment is just a small attempt at humor, because the fact is I have been a student and practitioner of time management for many years. Still, I found the book *Excellence Through Time Management* to contain valuable new ideas among many I had heard or read before.

The flyleaf touts the book as "fast-paced and easy to read" and that it is. Covering only 135 pages (large print, too) the text moves swiftly through twelve chapters of from seven to twenty pages each. The book's readability is enhanced by its being derived from seminar presentations made by the author. It's a compilation of his best admonitions and examples.

One is impressed just by reading the author's acknowledgments, as several management heavyweights, among them Peter Drucker and Alec MacKenzie, are recognized. Later, some of their best thoughts are quoted.

To set the theme for the book, Winwood tells us that the sort of time management which leads to more productivity and greater excellence is rooted in event control. He introduces the idea of the "event control continuum," which suggests that as our degree of control over events decreases, so must our adaptability to changing events increase. As the reward for controlling events, Winwood cites increased self esteem. He says, "Your personal self esteem is enhanced when you are in control and it suffers when you are out of control. People who maintain a healthy, positive self-image are more productive, more effective people—they take control of events over which they can effect control." Those of us in physical plant maintenance can cite numerous personifications of this notion in people with whom we've worked.

The author next discusses such time-robbers as interruptions, procrastination, and changing priorities, then leads into an argument that espouses planning as the key to control. Several oldie-but-goodie management maxims, such as Joseph Juran's "vital few and trivial many" concept of categorizing our tasks, are mentioned.

To elaborate on the planning process, the "productivity pyramid" is introduced. Obviously a device used by Winwood in his seminars, the pyramid has as its lowest level something called "governing values." His thesis is that all planning (our key to event control) must be based on our set of values. We must first, before planning, answer the question, "What values are to be served by the goals our plan will take us to?" Identifying these values and ranking them in order of importance (the author suggests writing them down) establishes the pyramid's foundation and leads us to the second level, which is long range goals.

While "long range" isn't defined, Winwood suggests that in this category we place those "Someday I'm going to . . ." events, the things we want to do sometime yet in our life, and set deadlines for doing each one. Having so, they become fixed in time as goals and are subject to management through event control. Several categories of goals and specific examples are offered to stimulate the reader's thought process for setting goals; e.g., lose fifteen pounds by next August 30, read five books by November 10, etc.

This section closes by observing that long range goals must be broken down into steps, each step becoming an intermediate goal. Intermediate goals are the third tier of the productivity pyramid and lead us to the peak level, which is the daily task list.

To develop the all important daily task list, Winwood suggests as a minimum, an appointment calendar, a daily "to do" list, a note pad, and a phone/address book. Several examples of each device are mentioned, with illustrations and instructions for use. Tips for maximizing the productivity opportunity of every minute are offered.

The text next discusses the use of a time log to ascertain how our time is presently being spent. Knowing this we can better determine what changes in behavior we must effect before engaging in event control.

Perhaps our time log has highlighted certain time wasters that have crept into our behavior. Winwood tells us how to control procrastination, interruptions, paper clutter, and unproductive meetings—four of the most notorious time wasters. One interesting note is when Winwood poo-poos the time-honored tenet of handling each piece of paper only once (which I personally have never been able to do, try as I might). Winwood says, "Like a perfectly clean desk, it is a nice idea, but also impractical and unproductive." Hear, hear! He then offers the alternative adage, "When you handle a piece of paper, do something productive with it." Like throwing it away. Hear, hear again.

As a change of pace, the author offers ideas on motivating ourselves and those around us. Personally, I'd have liked much more on this topic than the book contains. Of several profound observations, the most meaningful to me is when he says, "People operating at the love level require very little supervision. They will operate independently—because they 'love doing the job well'—they care as much or more than their supervisors about the job to be done." Again, as physical plant administrators we covet this type of person and strive to motivate all our associates to operate at the "love" level.

The book closes by urging the reader to rid himself or herself of any bad habits the reading has revealed, and extols the virtue of good time management techniques habitually practiced. Winwood offers a powerful poem regarding habits—one which could well find its way into a frame on the office wall of many a supervisor.

Anyone whose profession is resource management, and particularly those of us in the plant maintenance business where 70 to 80 percent of our resources are human effort, will find this book most worthy of inclusion in his or her professional library. For someone just beginning to explore the area of time management, it's an excellent primer; for the long-time student, an excellent refresher and reinforcer.

Excellence Through Time Management is available from The Franklin Institute, Inc., P.O. Box 2068, Salt Lake City, UT 84110.

—Charles W. Jenkins
Director of Physical Plant
St. Mary's University
San Antonio, Texas

Quick Management Help

Leadership and the One Minute Manager, by Kenneth Blanchard, Patricia Zigarmi, & Drea Zigarmi. New York: William Morrow and Company, 1985. 106 pp. $15, hardcover.

Leadership and the One Minute Manager is the third book in the One Minute Manager series. It continues the tradition of the first two books by being well written and offering concrete suggestions or ideas for improving your managerial capability. It fully explains the concepts of situational leadership, presents the four styles of leadership used, and explains how the style you use should tie in with the development of your employees.

Situational leaders utilize four styles of leadership in dealings with their subordinates. They change their leadership style depending on the situation and the person they are working with. This type of leader truly practices the saying, "Different strokes for different folks," and is not adverse to using different leadership styles with the same person. "Nothing is so useful as the equal treatment of unequals" is the situational leader's key phrase. These four leadership styles are defined as:

Directing. Provides specific instructions and closely supervises task accomplishment.

Coaching. All of directing, plus explains decisions, solicits suggestions, and supports progress.

Supporting. Facilitates and supports subordinates' efforts toward task accomplishment and shares responsibility for decision-making with them.

Delegating. Turns over responsibility for decision-making and problem-solving to subordinates.

To become a situational leader, you must learn three skills: flexibility, diagnosis, and contracting. Flexibility is being able to use each of the four leadership styles with confidence. Diagnostic skill comes by being able to recognize what development level the person you are working with is at. Contracting is deciding with employee what goals you both are aiming for, the standards on which you are evaluating performance, and what leadership style you will be using on each of the goals.

Properly utilizing the diagnostic skills to determine a worker's development level gives you, the manager, a clear idea as to which leadership style you will use with that worker. To further explain, the development level of a worker is determined by his competence and commitment. Competence is defined as a function of knowledge and skills that can be gained from education, training, and/or experience. Commitment is defined as a combination of confidence and motivation. The four development levels based on combinations of competence and commitment are shown below. The appropriate leadership style for each of the development levels is also shown.

DEVELOPMENT LEVEL	DESCRIPTION	LEADERSHIP STYLE
D1	High commitment/ Low competence	Directing
D2	Low commitment/ Some competence	Coaching
D3	Variable commitment/ High competence	Supporting
D4	High commitment/ High competence	Delegating

To train people to be good performers you must:

1. Tell them what to do.
2. Show them what to do.
3. Let them try.
4. Observe performance.
5. Praise progress or backtrack and start again.

The third skill, contracting, is very important to making the whole situational leadership system work. The contracting procedure is described below:

1. Set goals—the manager and subordinate agree on the goals and performance standard/measures. Goals should be SMART—*S*pecific, *M*easurable, *A*ttainable, *R*elevant, *T*rackable. Goals should also be limited to three to five.

2. Diagnose the development level—manager and subordinate agree.

3. Match development level with appropriate leadership style—manager and subordinate agree.

4. Deliver the leadership style—good performance, keep moving to next higher leadership style. Poor performance, keep moving to next lower leadership style, and if necessary return to start.

The authors met their intention with me, for now that I have been introduced to the idea and techniques of situational leadership, I plan to try it. The book is extremely readable and is only 106 pages long. I believe that any manager would enjoy reading this book because it will cause him or her to think about the leadership style he or she is currently using. The phrases alone would make this book worth reading, but the logic used in the development of the situational leadership game plan adds to the value. This book should be added to each manager's library.

Leadership and the One Minute Manger is available from William Morrow and Company, Inc., 105 Madison Avenue, New York, NY 10020; 212/889-3050.

—**Willard D. Jones**
Director of Facility Management
Applied Management Engineering, PC
Virginia Beach, Virginia

In Brief

Fairmont Press is a regular publisher of technical books related to facilities management issues. Recent titles include:

Compressed Air Systems, by E.M. Talbott, 184 pp.

Fundamentals of Noise Control Engineering, by A. Thurmann & R. Miller, 287 pp.

Industrial Cogeneration Applications by Dilip R. Limaye, 299 pp.

Introduction to Efficient Electrical Systems Design, by S. Ayraud & A. Thurmann, 249 pp.

Principles of Waste Heat Recovery, by R. Goldstick & A. Thurmann, 266 pp.

Solutions to Boiler and Cooling Water Problems, by C.D. Schroeder, 225 pp.

All the books are hardcover with illustrations and are available for $43 each from Fairmont Press, Dept. 1113, 700 Indian Trail, Lilburn, GA 30247; 404/925-9388.

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The National Institute for Work and Learning has released two new booklets: *Higher Education and the State—New Linkages for Economic Development* (1986, 35 pp.), and *A Better Fit Between Unemployment Insurance and Retraining* (1986, 40 pp.). NIWL is a private, nonprofit policy and research organization established in 1971 that seeks to improve the relationship between work and learning through research, pilot projects, case studies, technical assistance, and other programs.

For copies of the booklets and a complete publication list, contact Cynthia Chick, Publications Administrator, NIWL, 1200 18th Street, N.W., Suite 316, Washington, DC 20036; 202/887-6800.

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University Libraries in Transition: Responding to Technological Change details a case study by the National Association of College and University Business Officers (NACUBO). The study looked at the use of automation at four major research universities: the University of Georgia, Princeton University, the University of Illinois/Urbana-Champaign, and New York University. The schools have all incorporated a variety of advanced technologies in their libraries. The study was conducted under a grant from the Council on Library Research.

University Libraries in Transition is available for $15/NACUBO members, $22/nonmembers from NACUBO, One Dupont Circle, Suite 510, Washington, DC 20036; 202/861-2500.

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Energy Technology XIV: Changing Times for Energy Industries is the newly released proceedings from the 1987 Energy Technology Conference and Exhibition held April 14-16 in Washington, D.C. The proceedings look at state-of-the-art technologies and money-saving energy strategies submitted by conference participants. Topics covered include cogeneration, ratemaking, demand-side management problems, how the Tax Reform Act of 1986 affects energy equipment and systems, photovoltaic system technology, energy efficient lighting, natural gas utilization, energy efficiency in buildings, heat pump technology, and future trends in energy management systems. Illustrations and charts are included.

The 1,326-page *Energy Technology XIV* is available for $78 from Government Institutes, Inc., 966 Hungerford Drive, #24, Rockville, MD 20850; 301/251-9250. ■

Classifieds

Available Listings

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Rates

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Closing dates: **August 28** for the Fall issue; **November 25** for the Winter issue.

APPA-FM3930.classifieds

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Clarification

In "The Cogeneration Project at Cornell University" by Robert R. Bland *(Spring 1987)*, the vertical right axis on Figure 4 (p. 23) was not labeled. It should have been marked "IRR %". Two labels were left off Figure 5 (p. 24). The bottom line should have been marked "Capital Cost (M$)"; the left vertical axis should have been marked "N.P.V. (M$)".

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