# Power Shortage Costs and Efforts to Minimize: An Example

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## NOTICE



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ABSTRACT

This report presents estimates of shortage costs for a prolonged electric power shortage in Key West, Florida. Equipment failure dropped capacity 10-20% below peak demands for several weeks, and the isolated island system did not allow power transfer from other systems. The following willingness-to-pay estimates are discussed and presented as a complete assessment of all impacts from shortages to non-residential user: business establishment loss of $2/kWh; employee loss of 10¢/kWh; consumer (e.g., restaurant clientele) loss of 20¢/kWh. The residential electric power loss was only about 5¢/kWh, but it appears to depend heavily on the conditions during the shortage.

## EPRI PERSPECTIVE

### PROJECT DESCRIPTION

This study is one of four parts of ongoing work under Research Project (RP) 1104 on the value of reliability to consumers. A second study is a case study of the 1976-77 winter gas shortage; its objectives are to develop methodology and to estimate parameters for natural gas shortages. The third study subject is the theoretical economic aspects of the shortage problem. The fourth study is constructing a methodology to measure consumer's valuation of reliability and designing survey methods to obtain data before shortages occur. These other studies will be reported in forthcoming EPRI publications.

Data for this study were obtained from interviews with City Electric System employees and their customers in Key West, Florida, and from working documents provided by the City Electric System and others in the area.

The shortage investigated was one in which users were periodically disconnected over a 26-day period; actual disconnection for each feeder was about 6% of the hours in the period. The measure used in evaluating the cost of the shortage is the willingness to pay to avoid the shortage. This measure is expressed as cost per kWh curtailed. An estimate of cost per kWh curtailed allows comparison between energy and capacity shortages, comparison among shortage events within electric power, and comparison among electric power and other energy shortages.

### PROJECT OBJECTIVE

The case study reported here was undertaken at the suggestion of EPRI industry advisors to investigate the economic and social consequences of power outages that occurred in Key West, Florida, during the summer of 1978. EPRI's main objectives were to test and further develop methodology developed in work under RP1104-1 and to actually quantify the economic and social costs of shortages of electricity in one specific situation. There are indications that the Key West shortage is more typical than it would at first seem.

A major objective of the Key West City Electric System, which participated in the study, was to gather data on the value its consumers place on reliability in order to assist its future planning. An equally important objective was to make the experiences of the Key West City Electric System available to other utilities.

## PROJECT RESULTS

The estimated $2.30 cost per kWh curtailed for the shortage that occurred to Key West nonresidential users in the summer of 1978 is considerably more than the average price of electricity in Key West, which is about $.05 per kWh. The total cost of the shortage to customers was estimated to be $18.9 million. The reduction in income to the City Electric System amounted to about $315,000 during the brownouts.

Recommendations of this study include ways that utilities can greatly reduce user impacts by shortage planning both before and during the shortage event. Five major elements in shortage planning that will reduce the misfortune of the event include:

- Establishing a command post for decision making and for making news releases
- Preplanning a basic disconnect schedule including partial disconnect plans
- Identifying emergency equipment, government agency help, and other utility stand-by equipment
- Preplanning a voluntary conservation effort
- Preparing an inventory of critical users, e.g., life support users and location of production facilities that need early warning.

Preplanning is a form of insurance like capacity reserve margins. As in all insurance, it does not prevent the event from occurring.

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# CHAPTER 1

## SUMMARY

The objective of this effort was to study an actual electricity shortage to determine (1) the cost to users -- i.e., their willingness-to-pay to avoid a shortage such as that which occurred, and (2) the desirable supplier planning that can be utilized once a shortage becomes unavoidable. Study results are also valuable inputs for determining adequate reliability, but this was a secondary study objective.

This study was made possible through the cooperation of City Electric System employees and their customers in Key West, Florida. City Electric System (CES) management desires to help other utilities to:

(1) Develop a program to reduce shortage impacts;
(2) Understand actual impacts;
(3) Avoid last minute supplier action during shortages.

EPRI, Jack Faucett Associates, and City Electric management emphasize that this study contributes understanding of user impacts and suppliers emergency efforts for shortage situations, regardless of why or when a shortage occurs.

This is not a study of events causing the shortage and it is not a survey on suppliers' adequacy of preparation for shortages. The specific shortage scenario is presented only to relate the severity and nature of the shortage that generated shortage costs in Key West. The suggestions for supplier preparation are presented only to help other utilities determine if they have made all desirable preparation.

### INPUTS FOR PLANNING

The actual shortage event in Key West, Florida, and the comprehensive impact evaluation in this report provide a much-needed perspective and much-needed quantitative estimate for all forms of suppliers' decisions on reliability, on assisting users during a shortage, and on curtailing users. Utility planning requires considerable detail, but the following brief outline is a useful summary:

1. Valuable Information on Users
   a. Develop an inventory of life-support users who can be given a portable generator and, thereby, avoid keeping an entire feeder on;

b. List large users with critical uses who should be warned prior to rotating blackouts;

c. Identify loads that can be voluntarily trimmed (postponed) so that public appeals can be effective.

2. Command Post Operation

a. Establish power for assured command post operation;

b. Plan public appeals and news releases;

c. Differentiate energy and capacity shortages.

3. Pool of Back-up Facilities

a. Either the Government or an organization of utilities can develop a pool of emergency equipment.

COSTS PER KWH OF SHORTAGE

There are many measures such as cost/user, cost/event, cost/capacity unit, and cost/energy unit. The best single measure and best summary is cost per kWh, because it can be translated into other measures as appropriate. For example, an estimate of cost/kWh allows easier comparison between energy and capacity shortage, comparison among shortage events within electric power, and comparison among electric power and other energy shortages.

There are important details on the Key West shortage, but the following summary is useful prior to reading the entire report:

| | Cost/kWh | Cost for Total Shortage (000) | Market[a] Value of Elect. (000) | Shortage[a] Level |
|---|---|---|---|---|
| • Production and Sales (i.e., non-residential) | | | | 4.8% for 26 days |
| Producers, (e.g., auto repair, stores, schools) | $2.00 | $16,000 | $1,042 | |
| Employees | | | | |
| Wage loss | .10 | 800 | | |
| Comfort | Insig. | | | |
| Consumers | .20 | 1,600 | | |
| Macro-Effects | Insig. | | | |
| TOTAL | $2.30 | | | |
| • End-Use of Power | | | | 7% for 26 days |
| Residential comfort and convenience | .05 | 500 | 588 | |
| Fires, freezing, etc. in home | Insig. | | | |
| • Special | | | | |
| Crime, looting, etc. | Insig. | | | |
| Traffic flow and other disrupted patterns | Insig. | | | |
| TOTAL | | $18,900 | $1,630 | |

[a] The cost of electricity during the 26 day period and percentage hours that users were disconnected.

TABLE 1: CE SYSTEM CAPACITY

| | Unit | Service Area | Name Plate (Megawatts) | Dependable Peak (Megawatts) | Availability MW | Availability Period |
|---|---|---|---|---|---|---|
| A. | Peaking Units | | | | | |
| | 1 | C | 2 | 2 | 0 to 2 | July 28 to Aug 22 |
| | 2 | C | 2 | 2 | 0 to 2 | July 28 to Aug 22 |
| | 3 | C | 2 | 2 | o.k. | July 28 to Aug 22 |
| | 4 | B | 2.3 | 2.3 | 0 to 2 | July 28 to Aug 22 |
| | 5 | B | 2.75 | 2.75 | o.k. | July 28 to Aug 22 |
| | 6 | A | 2.75 | 2.75 | 0 | Aug 11 to Aug 22 |
| | Sub-Total | | (13.8) | (13.8) | | |
| B. | Steam Turbine Generator Units | | | | | |
| | 7 | A | 5 | 5 | 0 to 5 | July 28 to Aug 7 |
| | 8 | A | 5 | 5 | 2.5 max | July 28 to Aug 7 |
| | 9 | A | 16.5 | 15.5 | o.k. | July 28 to Aug 7 |
| | 10 | A | 16.5 | 15.5 | 0 | July 28 to Aug 7 |
| | 11 | A | 16.5 | 19.0 | 0 | Total of 12 hours |
| | 12 | C | 37.0 | 37.0 | 0 | July 28 to July 29 |
| | Sub-Total | | (96.5) | (97.0) | | |
| C. | Total CES Equipment | | 110.3 | 110.8 | | |
| D. | Emergency Additions | | | | .5 MW Navy[1/] | |
| | | | | | .5 MW Navy Operated[2/] | |

[1/] Loaned to CES

[2/] Navy owned and operated, to reduce demand on CES

CES FACILITIES AND THE SHORTAGE SCENARIO

Table 1 shows the electric power production facilities as of July 1, 1978 (i.e., the expected capability prior to system failure).

The total expected capacity was 96.5 MW steam generator capacity and 13.8 per peaking unit capacity, giving a total of 110.3 MW for peaks that have always been under 70 MW. The system peak demand for July and August, 1977, and for selected intervals in 1978 are shown in Figure 1. The peak demand was expected to be approximately 64 MW in the 1978 summer. Therefore, the 51 MW that was generated during several days was 20% below a 64 MW peak, and 11% below a 58 MW typical demand as indicated in Figure 1.

The system availability fluctuated between 45 and 58 MW during the July-August 1978 period. One specific day is shown in Figure 2, but this supply is only an example of capacity rather than typical capacity limits.

One summary of demand, supply, and shortage is the energy units (kWh) shown in Table 2. The 29,160 MWh is projected demand for the 624 hour period under no shortages (and accompanying public appeals for conservation). CES net loss of conservation was approximately 6,800 MWh with

TABLE 2: THE JULY 28 - AUGUST 22 SHORTAGE PERIOD

| | MWh | % | Capacity |
|---|---|---|---|
| • Level of Demand | | | |
| Estimated Demand | 29,160 | 100.0 | 64 MW Max. |
| CES Facility Supply | 22,467 | 77.0 | 51-58 MW |
| Navy Emergency Supply | 339 | 1.2 | |
| User Conservation | 4,915 | 16.9 | |
| Disconnected Feeders | 1,439 | 4.9 | |
| • Hours of Outage | | | Hours[a/] |
| Total Hours During Equipment Failure | | | 624. |
| Hours of Shortage (approx. 15 hrs/day) | | | 390. |
| Maximum Feeder Outage During Period | | | 59.34 |
| Total Feeder Hours of Outage | | | 898. |
| Average Outage Per Disconnect | | | 1.13 |
| Longest Continuous Feeder Disconnect | | | 2.92 |
| Maximum Feeder Disconnect in 24 hours | | | 5.33 |

[a/] Demand exceeded capacity 390 hours during the 26 days (624 total hours).

reduced system income by approximately $315,000 during the 26 day shortage period.

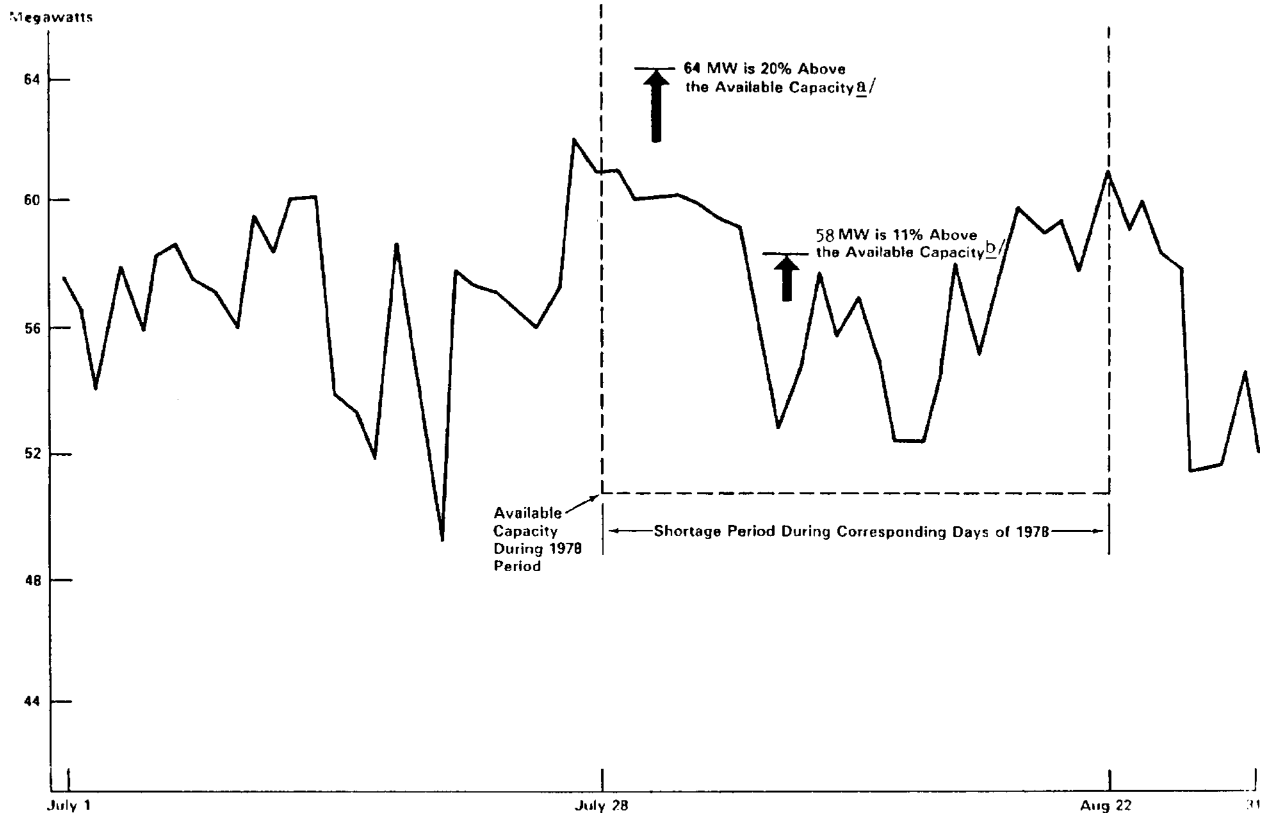



Figure 1: DAILY PEAKS DURING JULY AND AUGUST 1977

a/ 64 is projected peak for 1978

b/ 58 is average over period for 1977

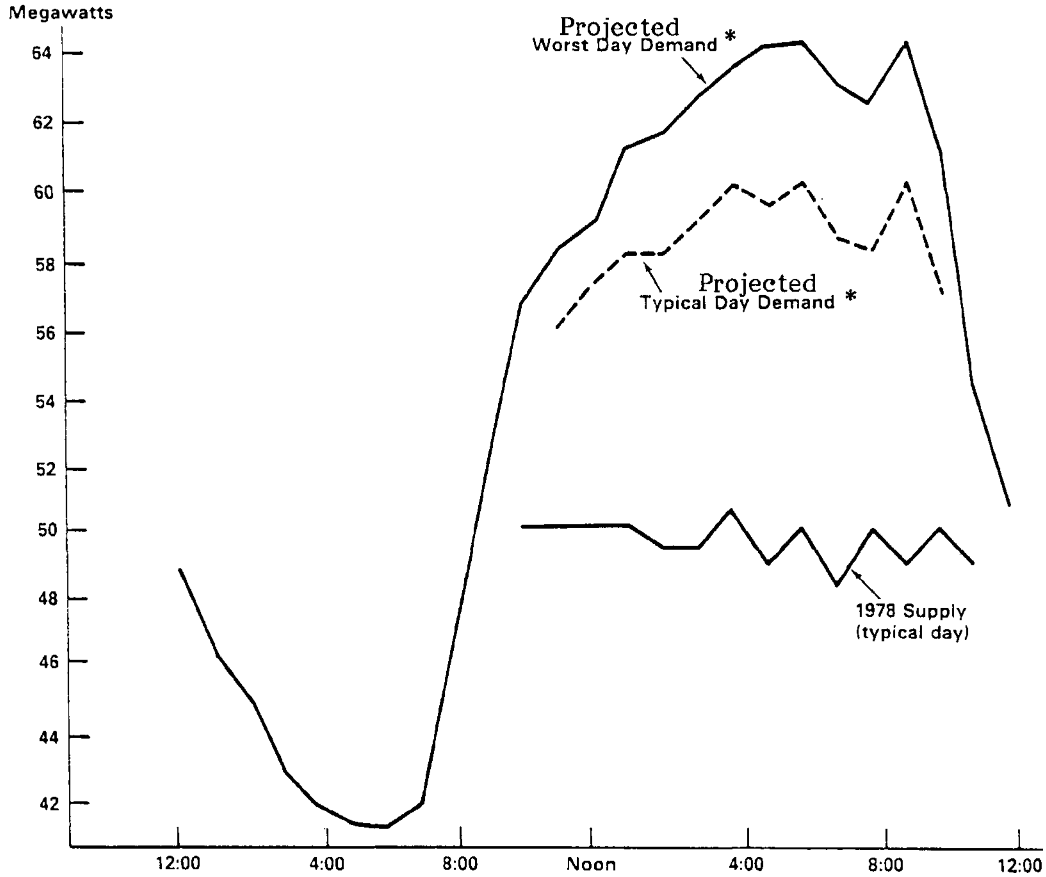



FIGURE 2. DAILY LOAD CURVE (Estimate for Shortage period)

* Projected by analyst (1977 pattern with level increased by 10%)

There are other expenses during the brownouts such as additional overtime contract labor, equipment repair over and above that planned for, and purchase of new equipment. These expenses do not show in this report.

It is interesting to note that the customers conserved 16.9% of the energy they would normally have used[a/]. It was only necessary to disconnect feeders so as to reduce the MWh by 4.9%.

The generation from the old Navy Diesel Plant only supplied .53% of the CES total, but this generation eliminated the dropping of additional feeders. The special effort to get this plant on line in a minimal time is a credit to the CES staff.

A second Navy Generation Plant also helped relieve the generation problem by supplying Navy directly.

CES is pleased with the way the general public reacted to this problem and adapted their life styles to cope with the condition.

The CES crews worked long and strenuous hours to keep as much equipment on line as possible. They were also in the field shedding loads. Their performance was outstanding.

The Utility Board and the City Commission tried to have Key West and the lower Keys declared a state-of-emergency; this would have brought aid but it did not occur. The Utility Board tried to obtain emergency equipment from the federal government, but with very little success.

There were some utilities and other firms that would have leased emergency units to CES, but the transportation and other costs were too high, and installation time too long.

<u>PRE-PLANNING CAN REDUCE IMPACTS</u>

Optimum reliability designated by Point "a" requires a prior sub-optimum in order to minimize total societal cost -- it requires planning to cope with a shortage once

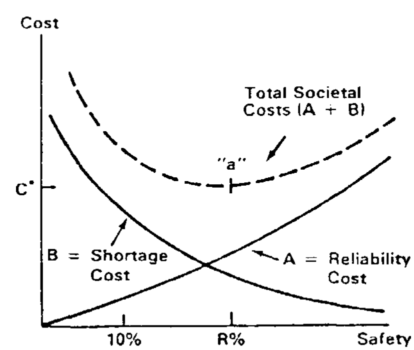


FIGURE 3. COST TRADEOFF

[a/] CES desired to give consumers full credit for their role in minimizing serious impacts it is unavoidable[a/]. Just as operating efficiency shifts the cost curve "A" down as far as possible, supplier planning for shortage situations shifts the shortage cost curve "B" downward as far as possible. To determine the R% optimum safety and to obtain the C* minimum cost designated by Point "a" requires an understanding of shortage costs as much as it requires understanding of reliability costs -- an understanding that permits us to determine the level at which the true incremental reliability cost equals the true incremental shortage cost; anything else creates higher than necessary societal costs.

This study contributes toward reducing <u>total</u> societal costs in both of the two categories discussed above.

A. Minimizing shortage impact when a shortage occurs:

1. The value of preplanning identified in this study may assist other utilities.
2. The utility's emergency plans reviewed in this study can be used by other suppliers.
3. The users' reflections presented in this study can help suppliers inform users and prepare plans.
4. The potential for government assistance and supplier pooling outlined in this report can reduce shortage costs and reduce safety margins.

B. Optimizing reliability to minimize total user cost:

1. The ratio of shortage cost to production cost in study results can be used to determine optimum (user justified) level of reliability.
2. The sacrifice from voluntary cutback provides a clue on the degree to which conservation should be used to complement reliability.

Shortages occur from a large increase in demand that exceeds the safety margin, or from a large decrease in supply that exceeds the safety margin. The Key West shortage was the latter.

[a/] Curve A in Figure 3 is the total cost of providing a specified safety margin; Curve B is the expected total shortage cost for various levels of safety.

## CHAPTER 2

## EVENTS LEADING TO SHORTAGE

The lack of maintenance was the major contributing factor for outages that occurred during the Key West shortage period (July and August of 1978). During the early 1970s, maintenance to City Electric System's (CES) equipment was cut back and was well below desired levels because of lack of funds. Two main reasons for the lack of funds were a decline of sales to the largest user - the Navy installation -- and the substantial price increase for fuel oil. Each reason was difficult to circumvent.

During the 1960s and into the 1970s the Navy loads increased at a rapid rate. Until 1970 all indications and information indicated that CES would be called upon to supply continued increases in Navy loads. In fact, in 1969, the contract was modified to provide for firm power supply by CES to all Navy facilities; at the same time the Navy agreed to place its limited generation on a "stand-by" basis.

In order to meet responsibility to its civilian customers as well as to the Navy, the CES raised $10,500,000 for expansion by issuing revenue bonds. The entire proceeds were dedicated to financing the construction of the 37 MW steam generating unit on Stock Island (see Unit 12 in Table 1) and the related transmission system improvements.

During 1969, CES received bids and issued letters of intent to purchase all of the major equipment for the new 37 MW Power Plant - a cost of approximately $3,500,000. In addition, CES called for and received bids for construction of this plant - a cost of approximately $4,600,000. This used 81 per cent of the $10.5 million bond revenue.

During the early part of 1970, a number of newspaper reports were circulated in Florida indicating that sizeable cutbacks in the Navy establishment in Key West were to be made in keeping with large scale trimming of the military budget. Officers of CES expressed their grave concern to local Navy personnel over these repeated news stories, but they could not obtain any firm indication that Navy facilities would not be cut back in Key West, and no indication if a decision were forthcoming. No reliable information could be obtained on the Navy's future electric needs.

City Electric System was faced with an extremely serious decision on whether to continue with the planned system expansion (which was well underway) even with a strong possibility of sizeable reduction in Key West Naval facilities. It might have been better to terminate commitments, sustain several millions of dollars in cancellation penalties and risk some lack of responsibility to provide normal service to the people in Key West.

Faced with this situation, CES officers attempted to negotiate amendments to the existing contract with the Navy which could insure CES' financial solvency should Navy facility reductions materialize. In the judgment of the CES' Utility Board, this course represented the only logical course open to the CES, short of possible default under their contract obligations to the Navy if they were to fulfill their responsibility to all other utility customers.

Conferences were held with Navy personnel in Charleston in June, 1970, and also in June and July with Navy officers in Washington, including Assistant Secretary Sanders, the Naval Facilities Engineering Command, and the Office of the Chief of Naval Operations. At all meetings CES attempted to obtain some indication from the Navy upon which CES could rely -- information regarding probable levels at which its Key West facilities would be maintained, and information on whether the contract could be amended to safeguard the CES from possible default should the Navy drastically decrease their load. Some assurance on both the foregoing points was considered essential by the CES Board, because it was faced with the construction of the facilities or, in the alternative, to abort the project and accept an immediate termination loss of well over $2,000,000. CES was unable to obtain assurances on either point.

Faced with the possibility of a power deficiency and the very substantial financial liabilities, the CES' Board in August voted to proceed with the construction of the generation plant (Unit 12 in Table 1). However, by doing this, CES placed its financial integrity in jeopardy to the degree that default on its bonds was possible under certain reductions in Navy power consumption.

Since 1970, the Navy has progressively reduced its facilities in the Key West area. The Navy Base (Truman Annex) was closed with no sea activity; activities at the Seaplane Base (Trumbo Point) have been reduced; Peary Court Housing has been demolished; and the original housing at Bigsbee Park is phasing out.

The decline in sales to the military was 20% of the City Electric System's total sales. Not only did the withdrawal of Navy facilities affect sales, it also affected the civilian community, which must pay for the system and provide investment capital.

A 400% increase in fuel oil prices was another major contributing factor in a poor financial condition. This caused the electric bills to almost double and caused the CES financial position to worsen because of the desire to avoid even further rate increases.

With the already large rate increase and the economically distressed community, the Utility Board was reluctant to increase electric rates in order to allow first class maintenance. The Utility Board did pass a 16% rate increase during this time, but most of it was absorbed in high inflation and, therefore, did not allow proper maintenance.

Coming into the 1978 peak demand period the expected peak demand was approximately 64 MW and the expected generator capacity was 110.3 MW. However, actual capacity was only 45 to 58 MW during the July-August 1978 portion of the peak season. During several days, 51 MW was generated. This was 20% below the 64 MW expected peak and 11% below the 58 MW expected average capacity during the shortage period; see Appendix D for greater detail.

CHAPTER 3

# DETAILED SHORTAGE COST ESTIMATES

Estimates reported in Table 3 are the shortage costs that occurred (and who was willing to pay to avoid them) in Key West during a capacity shortage from July 28 through August 22, 1978. These estimates reflect the shortage severity, the supplier actions, and the economic conditions that existed--i.e., they reflect all attributes in the shortage scenario.

## WILLINGNESS-TO-PAY

The most useful measure of shortage cost is the amount that affected parties are willing-to-pay to avoid the shortage. Stated otherwise, the cost is an amount for which society would be indifferent between having the shortage and paying the amount to avoid the shortage.

The shortage cost is precisely the measure that is required for determining proper safety margins in reliability. It is an estimate that a utility (and the regulatory commission) must know to carry out their responsibility to users; namely,

1. Increase reliability when the expected shortage cost exceeds the cost of reliability;
2. Decrease reliability when the cost of the last increment of reliability costs more than the shortages it prevents;
3. Minimize the cost of a given reliability and minimize the cost of a given shortage, so that items 1 and 2 are meaningful.

Among other things, the shortage cost estimates in this report will help determine optimum reliability and determine the minimum cost of both reliability and shortages at that optimum.

To summarize, willingness-to-pay is the proper measure for the shaded area to the right. It is also the proper criterion to use in determining how and when to curtail whenever a shortage is unavoidable -- i.e., it is the criterion to use in shifting the Shortage Cost Curve "B" downward as far as possible.

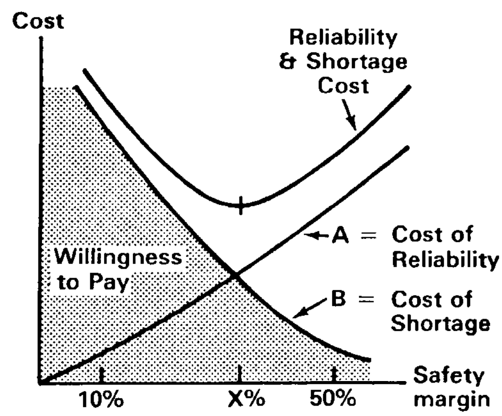



FIGURE 4. WILLINGNESS TO PAY

TABLE 3

DETAILED SHORTAGE COST AND RELATED ESTIMATES (JULY 28-AUG 22)[a]

| | Line | Normal Use MWh (1) | Normal Use $ (000) (2) | Shortage Cost Total (000) (3) | Shortage Cost Dollars Per kWh (4) |
|---|---|---|---|---|---|
| Group 1 - Producers | 1 | 20,400 | 1,042 | | |
| Extra cost | 2 | | | 10,000 | 1.50 |
| Unrecovered cost | 3 | | | 6,000 | .50 |
| Total Willingness-To-Pay | 4 | | | 16,000 | 2.00 |
| Group 2 - Employees | 5 | | | | |
| Wage loss | 6 | | | (1,600)[b] | (.20) |
| Willingness-to-pay to avoid wage loss | 7 | | | 800 | .10 |
| Willingness-to-pay for comfort | 8 | | | Insig. | Insig. |
| Total Willingness-To-Pay | 9 | | | 800 | .10 |
| Group 3 - Consumers | 10 | | | | |
| Residential direct use | 11 | 12,500 | 588 | 500 | |
| Voluntary | 12 | | | | (.01)[c] |
| Blackout | 13 | | | | (.04)[c] |
| Indirect use willingness-to-pay | 14 | | | 1,600 | .20 |
| Total Willingness-To-Pay | 15 | | | 2,100 | .25 |
| Group 4 - General Public | 16 | | | | |
| Macro-economic impact | 17 | | | Insig. | Insig. |
| Less services and greater losses | 18 | | | Insig. | Insig. |
| TOTAL, Groups 1-4 | | 32,900 | 1,630 | 18,900 | $2.30[c] |

Source: Working papers from interviews and the City Electric System Annual Report

[a] Willingness-to-pay is being willing to pay to avoid a specified loss

[b] Wage losses are evaluated as Willingness-To-Pay in Row 9

[c] Losses for residential shortages are not, and should not be included in deriving the $2.30/kWh for non-residential shortages.

MAJOR GROUPS WITH WILLINGNGES-TO-PAY

There are four major groups for which willingness-to-pay estimates are developed and presented in Table 3. Because there are differences in the type of loss within each group, a different method is used to estimate willingness-to-pay for each group. Types of loss by group are:

Group 1 -- Producers (commercial, industry and government services)

- Extra cost in coping with a shortage as in the case of inefficient production;
- Unrecovered cost from reduction in normal sales as in the factory overhead when a business is temporarily shut down.

Group 2 -- Employees (workers in Group 1 establishments)

- Wage loss;
- Poor working conditions (hot, cold, dark, etc.).

Group 3 -- Consumers

- Residential as a direct user of energy;
- Indirect user as a customer who waits for a restaurant to open or a garage to repair his car.

Group 4 -- General public response to overall economic conditions

- Macro-economic impacts;
- Less government services and greater special loss.

Although it was not possible to obtain reliable estimates for all sub-categories in this study, Table 3 shows all of the important sub-categories in order to show the entire spectrum of impacts.

The concepts for analyzing willingness-to-pay appropriate for each of the four groups are given in the next section.

Producer Model for Willingness-To-Pay

A producer can suffer damage of material, loss of sales, extra costs of substitute energy, reduced efficiency of labor, and other special losses. The important estimation task is to identify all losses while avoiding double counting.

Producers include all users other than residential--industry, commerce, and public services such as schools. They are called producers because they produce a service or product, whereas residential is a final consumer.

All producer losses can be evaluated in the two parts shown by the shaded area in Figure 5. The capacity shortage during the July 28-August 22 outage was approximately 20% as indicated by Point $q_2$ in Figure 5. As

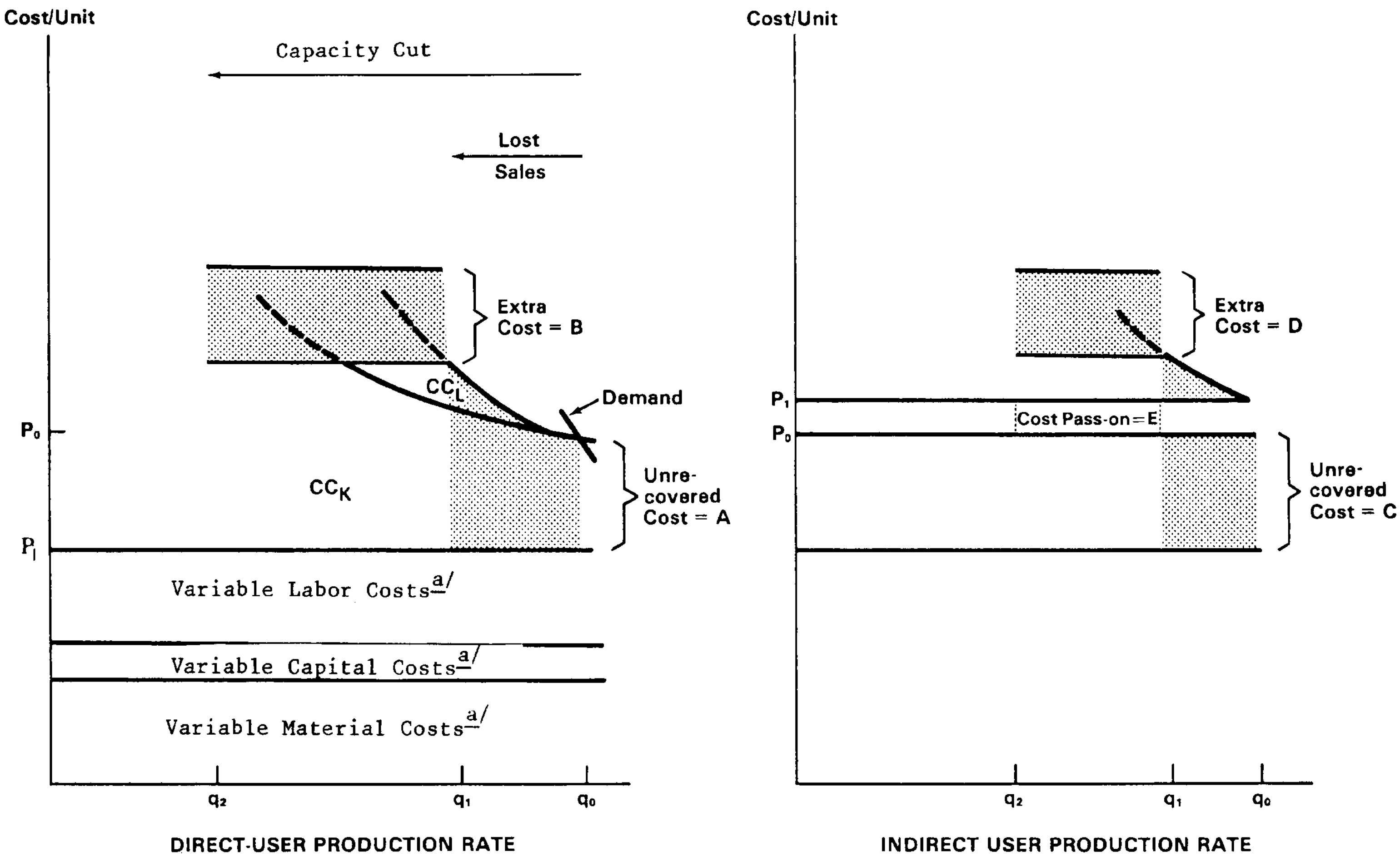



FIGURE 5. DIRECT AND INDIRECT PRODUCER COSTS

[a/] Cost $P_1$ represents the total variable components of labor, capital and material costs as shown.

shown, most of the producer losses were extra costs in contrast to unrecovered cost; see Areas A and B in Figure 5.

Sample observations do not permit detailed estimates of each specific component of the extra costs and unrecovered cost, but Table 4 gives some relative indications on component costs.

It is important to understand that many producer costs can be reduced greatly by warning or by special scheduling of the outage. The overall shortage cost estimates for Key West certainly reflect the benefits from warning and scheduled outages. Many customers would have preferred better warning and better scheduling, but this report does not include detailed analysis of what is possible in warning/scheduling.

The reader should appreciate that all cost estimates in this report reflect willingness-to-pay; other estimates such as total sales loss are reinterpreted in terms of willingness-to-pay. Many estimates are reported in the press, such as wage loss, sales loss, etc., but these are much larger numbers than willingness-to-pay.

Employee Model for Willingness-To-Pay

Employee losses occur when the producer also suffers losses, but they are losses over and above the producer willingness-to-pay.

Employee loss is difficult to evaluate because many effects are offsetting, as indicated below.

| Hypothetical Wage Change | Normal Production Schedule | Compensating Production Schedule |
|---|---|---|
| Producer A loses sales to Producer B | Wage reduction is an employee loss | Overtime wage is zero employee change |
| Producer A continues wage and pays for overtime to make up | Leisure value is a small employee gain | Overtime wage just offsets leisure loss |
| Producer A requires employees to change work schedule | Small leisure gain during normal hours | Larger leisure loss in off-normal hours |
| **Hypothetical Changes in Comfort and Convenience** | | |
| Poorer temperature & lighting | A net loss | |
| More work trips and more traffic problems | | A net loss |

All of the above potential employee losses were investigated, but none were large relative to producer losses. The total employee losses are estimated to be 5% of producer losses, or approximately 10 cents/kwh.

TABLE 4

COMPONENT COSTS

Part A: Types of Producer Costs

| | Relative Size |
|---|---|
| Extra costs:<br>Reduced efficiency<br>• Reduced employee output<br>• Alternative process | Approx. 75% of total |
| Damage<br>• Equipment<br>• Product loss | Only selected users |
| Substitute energy | Only selected users |
| Unrecovered costs<br>• Overhead loss<br>• Profits loss | Approx. 25% |
| Total | $2.00/Kwh |

Part B: Types of Producer Establishments

| | |
|---|---|
| Restaurant | Mostly loss in customers and a shift in work hours |
| Automotive repair | Loss of lights and electrical equipment often caused employees to be idle |
| Motels | Little net effect beyond client inconvenience and the restaurant portion of a motel |
| Public services | No significant increase in fire, crime, or other needs for public services |
| Food | Bakeries, ice cream parlors, and grocers suffered food losses occasionally |
| Stores | Stores were uncomfortably hot, too dark for customers' convenience, and handicapped by lack of cash register and phone operation |
| Special Cases | Printshops, for example, could lose a batch of work, and could incur loss from special equipment processes |

CONSUMER MODEL FOR WILLINGNESS-TO-PAY

The consumer of goods and services whose production was affected by energy shortage has two types of loss. First, he suffers the reduced value of goods/services as indicated by Area cdgh. For example, a restaurant meal after 10 p.m. has less value than one at the 7 p.m. planned event. Second, extra waiting and uncertainty of product introduces an extra cost -- Area abeg which the consumer would be willing-to-pay to avoid. For example, the auto is not repaired on the planned day and the bank cannot complete a loan on the scheduled meeting hour.

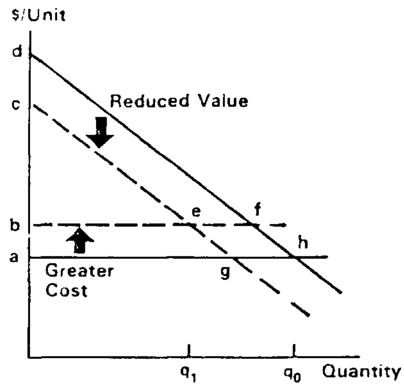



FIGURE 6. CONSUMER LOSS

The following list illustrates the types of consumer losses from shortage impacts on business in Key West:

| | Reduced Value | Extra Cost |
|---|---|---|
| Radio and TV | No reception when broad-cast or user's power was disconnected | Possible damage to equipment |
| Auto Repair | | Repair schedules were dis-rupted at user inconven-ience |
| Street Lighting | Traffic signals did not perform the usual function | Traffic jam from less street lighting |
| Banking Service | Bank equipment could not be used and paperwork delays increased | Customers would make unnecessary trips when planned meeting could not complete transaction |
| Laundry and Other | Hours of operation were less convenient | Necessary to reschedule |
| Public Facilities | Libraries and other facilities were closed when needed | |

The study included concerted effort to identify all significant losses, but few of the consumer losses were significant relative to producer losses. The total consumer loss was about 10% of producer losses, or approximately 20 cents/kWh.

Macro-Economic Model

There was no significant loss in this category at any time throughout the July 28-August 22 shortage period.

If tourists had left or failed to visit Key West in significant numbers, there could have been major macro-economic losses. This did not occur. There was publicity and there were tourist inquiries indicating concern, but no significant losses are apparent in any data or in opinions collected for this study.

Macro-economic impacts are difficult to explain unless there are specific losses to relate. Therefore, the types of potential macro-economic losses are not discussed. In essence, a loss in sales to an individual producer is a micro-economic loss; when these micro-economic losses multiply (possibly because of greater fear) and become greater than initial micro-impacts, they are called macro-economic impacts. See Appendix A for discussion of the hazards of making macro-economic impact estimates.

## CHAPTER 4

## SYSTEMATIC AND EARLY PLANNING

The user impacts when a shortage occurs can be reduced greatly by systematic planning done both before and during the shortage. It is unfortunate that so many people assume that shortages should not occur and, therefore, shortage planning is unnecessary. This thinking generally causes (1) safety margins to exceed levels that might otherwise be adequate and (2) user impacts for a shortage to be larger than necessary.

Pre-planning is a form of insurance just like safety margins. An insurance policy does not eliminate events, it just reduces the misfortune.

There are five major elements in systematic and early planning:

1. A comand post -- there will be important decisions and important news releases during a shortage;
2. A basic disconnect plan and schedule -- there is need for partial disconnection and need for scheduling disconnects;
3. Emergency equipment and other help -- the services of Government agencies and the emergency equipment of other utilities can be very helpful;
4. Voluntary conservation plan -- the potential saving and the proper focus of voluntary conservation should be pre-planned;
5. Inventory of critical users -- location of life-support users and location of production facilities that need warning is very helpful if availabe prior to a shortage.

The experience of other utilities during shortages can be valuable background. Because of this, the CES in Key West has supplied its views, description of shortage scenarios, and suggestions for minimizing impacts.

### PRIOR EXPERIENCE AND BASIC PLAN FOR CES

Major capacity reduction started on July 28th and continued through August 23, 1978. After August 23rd there were five (5) days that CES had to shed loads. These days are not included in this report because they were isolated cases.

On July 28, 1978, the City Electric System had no program to shed loads of the magnitude required to match capacity losses during July and August. In the past, sporadic short outages required disconnection of only a few predominantly residential feeders for short periods of time. With the shortage onset there was no indication that the shortage would last for almost a month. On the contrary, there was hope that the 37 MW turbine would be back on line in a few days. However, because of the severity of salt buildup on the rotor, it became evident that the unit would be off for a long time.

On July 28th, CES staff established a preliminary schedule for load shedding. This schedule was modified as time went on and by August 3, there was an estimated time when each feeder would be off. The goal was to turn off the same feeder at the same hour of day, enabling the customers to establish somewhat of a schedule for themselves. This could not always be adhered to because of equipment problems and unexpected changes in the daily load curves.

PUBLIC INFORMATION AND APPEALS FOR CONSERVATION

The local news media was kept informed throughout the period. Public appeals were made through radio and newspaper. Suggestions for conservation focused on the following items:

1. Turn off the water heater; the summer period permitted water heating to be eliminated or restricted to a few hours per day.
2. Use air-conditioning only at night; there was sufficient capacity for nighttime use of air-conditioning.
3. Cutback air-conditioning and hours of operation in commercial establishments; higher thermostat settings and closing of stores between 10 a.m. and 10 p.m. were especially helpful.
4. Cutback on use of stoves; less stove use and more one-pot meals were helpful without causing great inconveniences.
5. Use less of lights, T.V. and other equipment.
6. Dry clothes between 10 p.m. and 10 a.m.
7. Use dishwasher after 10 p.m.
8. Disconnect some street lights and illuminated advertising.

During the first week, CES established a list of large customers and their phone numbers and initiated a program to warn users just before their feeder was dropped.

There was assurance that people on life support equipment would not be disconnected. CES installed small generators at selected homes and CES electrical crews started the generators up before their feeder was disconnected. The Civil Defense supplied some of the generator units.

SYSTEM DESIGN FOR LOAD SCHEDULING

The list of feeders which could have been disconnected is shown in Table 5. The hours disconnected and special conditions are also shown.

TABLE 5. FEEDERS: CHOICES FOR DISCONNECTION

| Substation & Capacity | Feeder Number | Hours Off | User Characteristics |
|---|---|---|---|
| A: 13.8/4.16 KV[a] | 1 | 25.1 | Business and Residential |
| | 2 | 25.18 | " " |
| | 3 | 41 | " " |
| B: 13.8/4.16 KV | 4 | 43.8 | |
| | 5 | 16.27 | Hospital put on #13, 8/7/78 |
| | 6 | | Command post at CES |
| C: 13.8/4.16 KV | 7 | 33.71 | Commercial (Restaurants & Motels) |
| | 8 | 41.06 | |
| | 9 | 41.94 | |
| D: 13.8/4.16 KV | 10 | 43.25 | |
| | 11 | 42.07 | |
| | 12 | 43.61 | |
| F: 13.8/4.16 KV | 13 | 39.19 | |
| | 14 | 37 | |
| | 15 | 29.78 | Major Shopping Plaza |
| G: 13.8/4.16 KV | 16 | 45.57 | |
| | 17 | 24.5 | Airport |
| | 18 | 48.98 | |
| H: 13.8/4.16 KV | 19 | 10.01 | Radio Station giving public information |
| | 20 | 30.19 | Radio Station giving public information |
| | 21 | 15.85 | |

[a] Primary voltage/distribution voltage.

TABLE 5. (Continued)

| Substation & Capacity | Feeder Number | Hours Off | User Characteristics |
|---|---|---|---|
| I: 69/13.8 KV [a] | 22 | 25.08 | Commercial |
| | 23 | 33.16 | Major Shopping Plaza |
| | 24 | 59.35 | |
| | 25 | 36.07 | |
| | 26 | 32.05 | Major Shopping Plaza |
| J: 69/13.8 KV | 27 | 42 | Residential Area |
| | | 0 | Naval Air Station |
| K: | 28 | 41.84 | Navy Housing Area |
| | 29 | 21.71 | Sheriff and Police |
| L: 69/13.8 KV | 30 | 10.5 | Little savings from disconnecting |
| M: 69/13.8 KV | 31 | 52.7 | |

[a] Primary voltage/distribution voltage.

There were three major variables in the choice of feeders to disconnect, as indicated in the first three of the following categorization:

1. Critical use--police, hospitals, and life support were not disconnected unless backup power was assured.
2. Critical time of day--schools were cut only after school hours.
3. Warning--users who suffered large losses unless they had warning were cut during a pre-specified time.
4. All other--every feeder was scheduled for cutting the same time of day if possible, but this "all other" category was selected on sudden notice as necessary to prevent loss of voltage.

The average capacity for each of the 31 feeders was approximately 2 MW. In some cases, a partial feeder could be disconnected, permitting cuts of less than 2 MW increments.

There were many specific factors in the choice for pre-specified and flexible feeder disconnects. They can be summarized as follows:

1. Needed load cut--the load of the feeder relative to required load cut was important in minimizing outages. It was essential to drop enough so that generation capacity was not exceeded; and at the same time, it was desirable to keep as many customers with service as possible. An estimated daily load curve was developed and feeder loads were scheduled as appropriate for available capacity.
2. Type of use by time of day--e.g., restaurants were not disconnected during meal times whenever possible.
3. Emergency use--feeders for the two hospitals were never disconnected, even though they had emergency generation.
4. Time for adjustment--the police and sheriff's departments and airport were not disconnected until August 8th when there was assurance that emergency generation was adequate.
5. Critical military use--the Boca Chica Naval Air Station would have had safety problems and therefore 25% of system demand was not disconnected.
6. Valuable public service--the radio stations provided public information and made public appeals; small generation units were given to these stations to allow feeder disconnect.
7. Command post and critical service--the CES service building and operations communications center were not cutoff. However, all air-conditioning and unnecessary loads at these buildings were disconnected.

# APPENDIX A

## CONTRIBUTION TO THEORY AND MODELING

Understanding the contribution of this study to shortage cost theory and estimation models is much easier if they are compared with other shortage analyses. Therefore, the reader is referred to a forthcoming EPRI report on shortage cost estimation methodology [3].

Estimates and appraisals in this report require acceptance of many concepts, some of which are newly developed. Unfortunately, these concepts are not easily explained without study of the 100-page document in the forthcoming EPRI report [3].

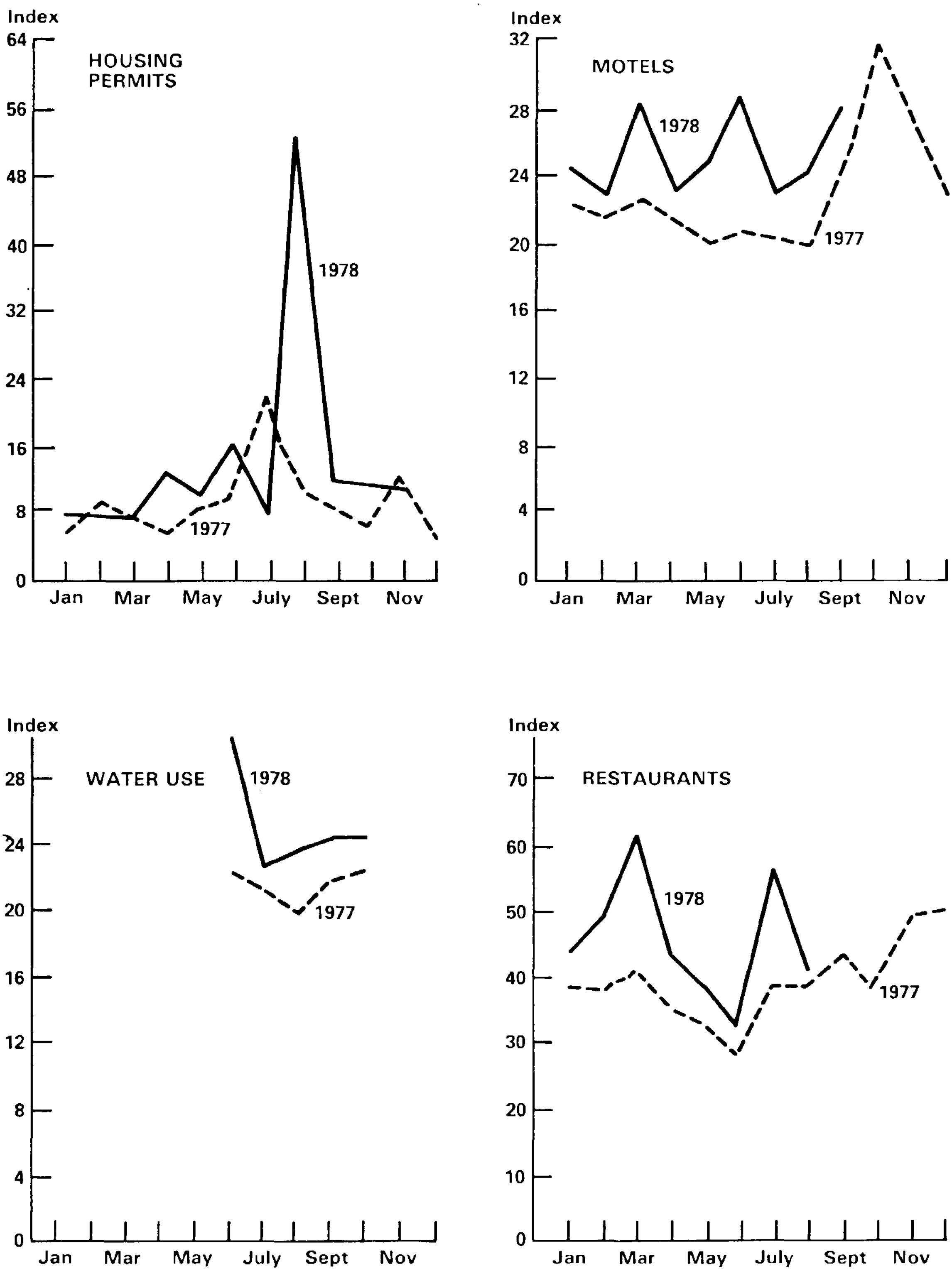
Figure A-1 is included to show the difficulty in using macro-data. Even though the restaurant data in the lower right shows an impact, it was only one of six available measures (four of which are shown in Figure A-1) that indicated an impact during the shortage period. One out of six is hardly conclusive data; however, the dip in restaurant sales becomes more meaningful when combined with the interview results from restaurant operators.

First, restaurants were most affected in the peak evening hours, and we could expect more impact. Second, clientele tended to switch to fast-food restaurants which operated with standby, but the cost of restaurant purchases was reduced nevertheless. Third, restaurant sales do not tend to be made up later, as in the case of, say, automobile repair. Fourth, restaurant temperature discomfort was greater than for barbecuing in the backyard.

The logic in the above observations was confirmed by a segment of restaurant owners who reported a loss in sales during the shortage period. However, certain restaurants were unaffected; and some even gained sales, as reported above.

Macro-data could not reveal the shortage impacts which produced a willingness-to-pay to have avoided the shortage. There is no hope of understanding a Key West type shortage impact without interviewing--very careful interviewing. The following examples illustrate:

- Housing starts increased 10-fold during the month of the shortage;
- 1978 showed an increase in economic activity over 1977 even during the shortage month;
- Gasoline sales were increased by persons who went for a ride during the disconnection, particularly if they had an air-conditioned car;
- Many sales reductions were merely postponed purchases.




Source: Private data from Richard Snyder [5].

FIGURE A-1. MACRO-INDICATORS

## APPENDIX B

## QUESTIONNARIES USED

Table B.1 is the questionnaire which guided indepth discussion with business establishments. The questionnaires proved helpful, but many insights were obtained from discussion outside the questionnaire.

Table B.2 in the questionnaire which guided indepth discussion with residential users of electric power. It was particularly difficult to elicit estimates of willingness-to-pay to avoid the July-August 1978 shortage; many of the immediate responses were "...I think the supplier should provide reliable service;...my bill is already too high."

The same project staff designed questions, conducted interviews and wrote this report; this aspect of the project plan was essential for advancing state-of-the-art in shortage cost analysis and for developing reliable estimates of shortage costs in this case study of electric power capacity shortage.

## TABLE B.1

## QUESTIONNAIRE FOR BUSINESSES

### Introduction

If you can tell us your impact from the electric power shortage last summer, we can better advise other utilities about consequences of outages.

Our objective is a comprehensive identification of all inconveniences and financial losses without identifying any individual such as yourself.

A. Damage:

1. What equipment or perishables, such as food, did you lose? $________

2. What condition was lost item and how often does the replacement outlay occur?

B. Sales loss for commercial establishments:

1. What loss in sales occured? $______________ or ____________%

2. What percent of these sales losses were made up later? __________%

3. What loss do you think the customer incurred where he reduced his purchase from you? __________% of sales value

C. Loss in productivity for commercial and industrial establishments:

1. What was the loss in productivity during the hours of shortages?

2. What percent of this loss could be made up during the normal workday of the employee?

3. What was the reduction in employee take-home pay?

D. Inconvenience and discomfort for employees and customers:

1. What was the temperature and lighting for employees?

2. What was the temperature and lighting for customers?

E. Shortage level and normal volume of activity:

1. How many hours was your power off?

2. What is your normal August electric bill?

3. How many employees do you have?

4. What is your normal August sales volume?

TABLE B.2

QUESTIONNAIRE FOR RESIDENTIAL

## Introduction

If you can tell us your impact from the electric power shortage last summer, we can better advise other utilities about consequences of outages.

Our objective is a comprehensive identification of all inconveniences and financial losses without identifying any individual such as yourself.

## A. Accidents or Damage

1. Did your household suffer any accident attributable to the shortage?
   ______________________________

2. Did you lose any equipment or perishables? ____________

3. Do you have any special need such as life support equipment? ________

## B. Inconvenience

1. How do you rank the following consequences from the shortage?

   Heat discomfort ____________
   Cooking schedule ____________
   Stopped clocks ____________
   Disrupted TV, radio, telephone, etc. ____________
   Street lighting and traffic flow ____________
   Closing of stores and restaurants ____________

2. Did anyone in your household lose wages or income? ________

## C. Worth of avoiding this shortage at your household, given it were to happen

1. Would you be willing to pay: a) Your annual $600 electric bill
   b) Your approximate $60 for that 4 weeks
   c) Your approximate $6 for the actual hours

2. If the utility would incur cost and spread it over all users what do you think is justified?

   a) Your approximately $600 annual cost
   b) Your approximately $60 August cost
   c) Your approximately $6 shortage period cost

## D. Shortage Level and Normal Electric Use

1. How many hours were you off? ____________

2. What is your normal August electric bill? ____________

## E. Hours of Shortage

1. What changes in hours or duration at a time would be better?

2. What warning would have helped reduce impact?

## F. What do you think would have been desirable and feasible?

## APPENDIX C

## NECESSITY FOR AND ART OF INTERVIEWING

Interviewing energy users for determining shortage impacts is hard work and tricky. The large number of interviews arranged for convenience of interviewees means hard work. The danger of misinterpreting questions and the temptation to vent complaints about energy trends require conscientious analyst efforts to avoid pitfalls in accurate representation of willingness-to-pay.

Like good econometrics, a good questionnaire and interview is a bridge--a bridge between what the analyst would most like to know and what the interviewee would most like to tell. Any researcher who designs a questionnaire and turns it over to the interviewee is virtually doomed; the bridge requires many adjustments and extensions that can be designed only when the analyst (who knows what he must eventually estimate) has opportunity to discuss with the persons providing data.

The following observations on Key West shortage victims indicate how the bridge was developed for this study:

1. Baseline producer volume--Producers were very reluctant to indicate sales volume, but were very willing to specify their normal monthly electric bill. Therefore, all losses were normalized on kwh loss in electricity without relating losses to sales volume as intuition might suggest.
2. Residential loss in comfort or convenience--Residential users were overwhelmed by the direct question on what they would be willing-to-pay to avoid an interruption but they were willing to choose one of the following choices on what they would have done to avoid the 26-day shortage:
    a. Pay twice the normal \$600 per year to avoid the shortage.
    b. Pay twice the normal \$60 per month to avoid the shortage.
    c. Pay twice the typical \$6 for the approximate 36 hours they were cutoff.
    d. Pay no significant amount.
    e. A pleasant overall experience in this instance because of greater socializing and greater feeling of helping reduce energy use.
3. Producer loss in sales--Producers were not able to give an overall estimate of loss in sales, but they were able to choose among the following:

a. $\$X_1$ sales were lost in the hours of shortage, but were made up in other hours of the same day or in days immediately following.

b. $X_2$ man-hours were lost per each hour that the power was off.

c. $X_3$ percent loss in productivity occurred during each hour of power outage.

4. Special losses such as fires--Rumors of fire losses and equipment damage were widespread, but an accurate feeling was established only when service agencies were contacted, as indicated below:

   a. Fire Department--they cited one fire caused by a stove that came on when electricity was restored, but they saw no evidence of any other fires or emergency condition during the shortage.

   b. Household equipment repair--companies with service contracts noticed a slight increase in repair calls for refrigerators, motors, etc., but there was no appreciable failure attributable to the shortage.

   c. Police--the police and sheriff records show no significant increase in crime or other disturbances.

There are many observations on interviewing, but the above indicate the need for careful planning and design.

There is no hope of understanding a Key West type shortage loss without interviews. All readily available indicators failed to show the actual impacts or gave misleading clues. Some of the examples are given below:

- Housing starts--this data is available for the precise region of interest; but, starts increased 10 fold in the shortage month because of a large hotel project.
- Change from year before--1978 was a substantial growth in summer activity over 1977; therefore, the external increase overshadowed the shortage impact.
- Gasoline sales and tax receipts--this measure can be obtained for the precise area, but extra vehicle use partly because of the shortage prevented this from being an indicator. For example, people would go for a ride to get out of a hot home condition, particularly in an air-conditioned auto.
- Consumer inconvenience rather than sales loss--many sales changes were merely postponing sales to another hour or another day; for example, the auto repair took an extra day but the loss is not reflected in readily available sales data.

Only if shortage analysis includes an estimate of willingness-to-pay to avoid the shortage will the analyst avoid all pitfalls, yet identify all impacts.

## APPENDIX D

## TECHNICAL EVALUATION OF THE SYSTEM

This discussion is not essential for understanding shortage impact--the main focus of this report. It is included to help other utilities understand how a shortage can, and actually did, occur.

In the Comprehensive Engineering Report for the year ending March 31, 1977, the CES consulting engineer (Reynolds, Smith and Hills) made the following evaluations.

> Key West Steam Plant (See the 59.5 MW in Units 7-11 in Table 1)--Over the past year a remarkable improvement in the overall condition of the Key West Steam Plant has been made. Nearly all of the significant problems indicated in the System Study have been or are in the process of being corrected.
>
> The overall appearance of the plant has also improved. Good housekeeping practices are being employed. Further improvements in appearance can only be achieved, however, by a complete repainting of the plant.
>
> The Stock Island Plant (See the 37 MW capacity in Unit 12, Table 1) --This plant is in good operating condition and overall appearance. There are presently no major recurring operating problems. Much of the work recommended in the (earlier) System Study has been completed.
>
> The lack of maintenance was the contributing factor for the brownouts. During the early 1970s, maintenance to City Electric System's equipment was cut back and was well below desired levels because of lack of funds. Two main reasons for the lack of funds were a decline of sales to the largest user--the Navy installation--and increased fuel costs--the substantial price increases for fuel oil. Each reason was difficult to circumvent.
>
> During the 1960s and into the 1970s the Navy loads increased at a rapid rate. Until 1970 all indications and information indicated that CES would be called upon to supply continued increases in Navy loads. In fact, in 1969, the contract was modified to provide for firm power supply by CES to all Navy facilities; at the same time, the Navy agreed to place its limited generation on a "stand-by" basis.
>
> In order to meet responsibility to its civilian customers as well as to the Navy, the CES in 1969 issued revenue bonds in the amount of $10,500,000. The entire proceeds were dedicated to finance the construction of the 37 MW steam generating unit on Stock Island (see Unit 5 in Table 1) and the related transmission system improvements.
>
> Some problems still exist at the plant and require further investigation and correction.

The above opinions of the consulting engineer verify the effort of the City Electric System since 1976 to spend the necessary money for maintaining the equipment; there was an effort to catch up on all maintenance that was deferred during the hard times.

In 1976, Reynolds, Smith and Hills made a feasibility report showing the System's long range plans. Considered in this report were different modes of generation and a transmission line to the mainland. The transmission line was shown to be the most feasible improvement over the long range.

They strongly recommended that the Utility Board move expeditiously in three efforts:

1. Culminate a Joint Ownership/Operation Contract with the Florida Keys Electric Cooperative Association, Inc. (FKE).
2. Negotiate a letter of commitment with FP&L (in conjunction with FKE) for firm energy purchase; the years and amounts were recommended in their report.
3. Initiate action to design the substation generation arrangement plant for Big Pine Substation and purchase the necessary land. Move the two peaking diesels--the 5.05 MW in units 4 and 5 in Table 1 to the new substation in time for service during the summer, 1978.

The consulting engineer gave several other important comments, as illustrated below:

> We forecast an overall average System growth rate of 2.5% per year through FY 1980 and 3% per year for the remainder of the study period.
>
> The FKE has been planning a system expansion program for the past several years and has been talking to CES personnel regarding this program. In order to meet an inservice date before the summer of 1979 for the Marathon-Islamorada line, the FKE is moving ahead with design at the present time. In numerous meetings during the past six months negotiations have taken place concerning joint participation in a complete tie line to the mainland for CES and FKE.[a/] That is, a connecting line involving the intermediate cooperative utility would allow sale of power to and from the FKE utility. These plans appear close to being culminated in a joint ownership/operational agreement between the CES and FKE as such an arrangement is shown to be feasible in this report.
>
> Phase I of this transmission project is joint participation with the FKE in construction of a transmission line from Marathon to Islamorada, and for the CES to construct a portion of their transmission line from

---

[a/] This is a connecting line, involving the intermediate FKE utility, and would allow sale of power to and from FP&L.

Marathon to Big Pine Key. Phase II is joint participation with the FKE from Islamorada to Tavernier, -- construction of a transmission line from Big Pine Key to Big Coppitt Key and Cudjoe Key to Big Coppitt Key.

CHANGES IN PLANNING SINCE JULY 1978

The City Electric System made changes in long range planning because of the brownouts. On the recommendation of the consulting engineers and others, CES purchased a 22 MW gas turbine to quickly augment available generation. This turbine was contracted for in October 1978 and was on line in December, 1978.

CES made other efforts to raise capital and made major repairs to existing power plants. There was a $7.2 million bond issue in January 1979; $5 million was spent for the new 22 MW gas turbine and for repairs in existing plant; $2.2 million is allocated for a portion of the transmission to allow exchange of power with FP&L. As of April 1979, CES is not contemplating construction of the total transmission line because of the lack of money. However, CES is trying to arrange funding for joint participation with FP&L in constructing the total transmission system.

The forecast of future loads is an increase in sales of approximately 2-3% annually. In approximately four (4) years the surplus Navy properties are expected to be developed. This will probably increase total sales by approximately 10%.

SEQUENCE AND WARNING IN CAPACITY LOSS

As stated earlier, CES was lacking maintenance in the early 1970's and was trying to catch up on maintenance when the capacity losses occurred in 1978. It was necessary to perform maintenance during peak periods--maintenance that would normally be done during the slack months of November and December or March and April.

Maintenance prior to August 28, 1978, had improved conditions; however, there were unfinished jobs such as the overhaul of the diesel peaking units, boiler work, retubing condensers, etc.

The following dates and discussion summarize the loss in capacity and indicate the lack of warning that can hurt planning:

On July 28, 1978 the expected peak demand was approximately 64 MW. On this day, the 37 MW turbine generator at Stock Island plant was taken off the line because of turbine problems. This reduced capacity over 40%.

The outage of the 37 MW plant was caused by large deposits of salt on the turbine rotor; the salt entered the steam system through condenser leaks. This unit had to have major repairs and was not back in service until August 29, 1978. After being put back in service this unit operated at a reduced load (22 MW) because of boiler problems.

On July 28, 1978 the CES had steam turbine generator #3--the 16.5 MW in Unit 9, Table 1--out of service for a major overhaul. The turbine rotor was being repaired in the manufacturer's repair facility in Tampa, Florida. The repair facility was instructed to work around the clock to repair the rotor and complete the work on this turbine. The manufacturer did a very good job and had the turbine in operation by August 7, 1978. As this unit was started, there were massive condenser leaks; and it could not be operated until August 14, 1978. Starting August 14th, it was operated at reduced load until the full 16.5 MW capacity was available August 29, 1978.

On July 28, 1978 the 10 MW in Units 7 and 8 in Table 1 were not fully available and a steam turbine generator (5 MW) could only operate at 2.5 MW because of a vacuum problem. This continued during the emergency period.

Another 5 MW generator was operated at reduced loads during most of the time because of equipment problems; it was taken off the line for short periods of time to make emergency repairs.

On August 11, 1978 one diesel unit (2 MW in Unit 6 in Table 1) was taken off line for the balance of the shortage period. The generator section suffered severe damages.

Prior to August 11, 1978 two peaking diesels in one subarea (2 MW each) and one (2 MW) in another subarea were shut down. These units were off line most of the remaining time during the brownouts.

On August 14 and 21, 1978 a 16.5 MW turbine was off line for approximately 6 hours each time to make repairs to a fan motor.

The new 22 MW generation capacity was on line by December 29, 1978; this appears to be a record installation time. This was made possible by the Utility Board actions, the manufacturer's accelerated schedule, the CES engineers' planning, and the contractors.

There are no foreseeable brownouts similar to those experienced in July and August, 1978. If for any other reason more brownouts occur, CES is better prepared to handle them because of the July-August 1978 experience. CES hopes that other companies can prepare for similar problems so that they will be better able to cope with the problems if, and when, fuel problems and limited generation expansion should cause brownouts.

## GLOSSARY

Board: The board of directors for the CES; it includes the CES Manager, but not the Assistant Manager.

CES: City Electric System; this utility serves all of Key West electric power needs; there is no natural gas utility.

Coop: See FKE.

FKE: Florida Keys Electric Cooperative; the utility adjacent to the CES and the utility that would provide transmission line between the CES and FP&L.

kwh: Kilowatt hour.

M: Thousand; for example, $1 MM is $1,000.00

MW: Megawatt.

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