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Discussion Series on PURPA Related Topics*

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METERING

BILLING

**INFORMATION
TO CUSTOMERS**

**LOAD
MANAGEMENT**

**MASTER
METERING**

*Based on Experiences from DOE Electric Rate Demonstrations

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Prepared by:
James I. Sturgeon
City Utilities of Springfield, Missouri
Springfield, Missouri
Under Contract No. FC01-77ZZ00335

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BILLING

*Based on Experiences from DOE Electric Rate Demonstrations

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The statements, findings and conclusions are the responsibility of the author and do not necessarily reflect or state those of the Department of Energy, City Utilities of Springfield, or those who have contributed data to this report.

ABSTRACT

Time differentiated billing of electricity consumption was more complicated than billing with traditional rates. A time differentiated billing process usually required augmentation of both hardware and software. This was especially true when billing was done from magnetic tape meter data.

Usually a translator and a minicomputer were required for billing from magnetic tape data. These were sometimes augmented with additional features such as a verifier, a printer and television display screen. The systems components were tied together by computer programs and it was connected to a mainframe computer via an additional program.

The process of augmenting this equipment was fraught with difficulty. While there were few delays due to late delivery of equipment, many Projects were required to spend considerable amounts of time training people to operate and maintain new billing hardware and to edit data, write, debug and augment programs and software packages. Even if billing was done from multidual meter data, additional steps were added to the process and programming routines had to be written.

All data had to be checked for accuracy and there were a number of reasons for flagging data for possible inaccuracy. Among these were: missing time pulses, a mismatch between the total kwh consumption from the meter dial and that computed from the tape, improbably large or small total consumption, or improbably high or low peak usage. Flagging data provided an indication to an editor that data had to be examined and, if possible, repaired. Estimation routines had to be developed for cases where data could not be repaired. All data had to be "cleaned" before it could be used in the production of the bill.

A TOU bill had many of the same components as a non-TOU bill, but additional itemization was usually incorporated. For example, a breakdown of consumption into peak and non-peak periods, price per kwh per rate period, the time-of-day of the customer peak demand and messages about shifting consumption to other periods was added to bills. Most of the Projects incorporated some or all of these features into their bills.

Customers reacted in a variety of ways, both to their TOU bills and to the Projects in general. Most of the Projects set up additional or special methods for handling these inquiries or complaints. In some Projects a single person was designated to handle all questions and calls were routed to that person. Others relied upon their usual customer representatives, but gave them additional training. Many of the customer calls were for additional information, but in at least one Project customer complaints were one source of discovering billing errors.

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THE DISCUSSION SERIES ON PURPA RELATED TOPICS

INTRODUCTION

The Discussion Series on PURPA Related Topics is composed of five volumes: Metering, Billing, Information to Customers, Load Management Techniques and Master Metering. These reports are based on twenty-five Demonstration and Implementation projects sponsored and directed during the past five years by the U.S. Department of Energy, Office of Utility Systems. Each of the topics bears directly on one or more of the federal standards contained in the Public Utilities Regulatory Policies Act of 1978 (PURPA). This volume, Billing, relates primarily to the Time-of-Day rates standard, PURPA IB(d)3. The experiences related in this report deal, in part, with the procedures and equipment which are affected when time-of-day rates are the basis for the billing process.

One goal of these reports is to describe how people in a variety of settings have dealt with the many practical issues in each topic area. Another is to highlight the lessons and summarize the experiences of the project participants. These reports do not stand as systems manuals or provide prescriptive guidelines on how to deal with these topics. Rather they offer an account for those charged with the responsibility of implementing PURPA requirements to learn from the insights and problems which occurred during the Rate Demonstration projects.

This series of reports will be useful to utility and regulatory people in judging the full scope of work related to these topics, anticipating problems and planning the spectrum of requisite activities.

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CHAPTER :
ONE : INTRODUCTION
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The DOE sponsored Electric Rate Demonstration Projects (Projects) were more than elasticity measurements, demand projections, usage figures, and statistical analyses. Behind each table and graph in the Project reports are experiences in planning and implementation of work which has been ongoing in each Project for several years. This second report on billing looks at the many field experiences in the Projects dealing with demonstrating how customers respond to Time-of-Use (TOU) rates.

This volume is not an engineer's, accountant's or computer programmer's manual, but an account of field activities involving many aspects of billing equipment and billing operations. The purpose here is to synthesize the experiences and highlight patterns and anomalies with specific examples. By so doing, it is hoped that the uninitiated will have the opportunity to learn from the experiences of others before themselves engaging in work with time differentiated billing processes.

A number of electric utilities and public service commissions will soon become involved for the first time in the implementation of the PURPA standard on Time-of-Day rates, IB(d)1: this report is primarily for their use. Information contained here, however, may also be useful to billing equipment manufacturers and consultants. They will have the opportunity to assess Project accounts of field experiences, providing a viewpoint which may ultimately aid in design and the preparation of installation and billing procedures.

Large volumes of data, daily logs, field reports and other documentation from the Projects serve as a source of information for this report. Follow-up interviews with Project personnel provided the detail and richness of first-hand experience.

Two general observations stand out in this report:

- Editing and processing magnetic tape meter data for billing purposes requires careful scrutiny at each point in the cycle. The process will usually entail some human judgment of the data at the editing stage and cannot be assumed to be automatic.
- The software packages which were purchased had to fit into the utilities' existing billing systems; thus it became necessary for extensive in-house understanding to be developed. The packages did not turn out to be a panacea for solving data processing problems.

CHAPTER :
TWO : BILLING EXPERIENCES: AN OVERVIEW
:

This chapter presents an overview of various aspects of the billing process and relates some of the billing experiences of the Projects. The chapter discusses some experiences and problems encountered during the Projects: 1) billing equipment, 2) billing and metering, 3) billing data processing, and 4) billing and customer relations.

Under most traditional rates the bill is calculated by simply multiplying the number of kwh's used times the appropriate price per unit. Even if the rate is a declining or inverted block, the data necessary for calculation are the number of kwh's, making bill preparation relatively simple. However, under time-of-use (TOU) rates the billing procedure is more complicated. A utility which converts to TOU billing will gain some insight from the Project's experiences as to how these complications may affect its billing procedures.

The billing process begins with the billing equipment, and this is the first area examined here.

BILLING EQUIPMENT

TOU requires data which are more specific than other billing methods, so new metering equipment is needed. In order to process the data, most utilities had to replace or augment their billing equipment and change their billing procedures, especially when the metering equipment involved magnetic tape meters. When magnetic tape meters are used, a translator and new or augmented software are required. In most cases the mainframe computer billing software will also have to be augmented, or entirely rewritten. Altered billing procedures and new investment in equipment and personnel retraining are needed.

The Projects used a variety of billing procedures and equipment. Some of them completely computerized the billing process. For example, in the Wisconsin Project the participating utility

purchased a translator (with verifier) and a minicomputer. Software was designed so that a minicomputer was able to process the metered data and send it to the mainframe.¹

Other Projects relied on hand calculated bills. In Arizona, a special routine was organized which by-passed the normal billing process and sent the billing data for TOU customers to specially designated people. These people manually calculated the charges and penciled them on the regular billing card. This card was then mailed to the customer along with a copy of the worksheet used to calculate the bill.²

Projects chose various methods to access new billing equipment. As we said, the Projects using magnetic tape meters had to have access to a translator. Some of the participating utilities already owned translators. Since Carolina Power and Light had been doing load research with magnetic tape meters for a number of years, the utility had a translator and minicomputer for tape processing. However, the existing billing equipment was augmented with another software package designed for the Project.³ Arizona already had a translator, but did not use it in billing TOU customers.

Another procedure was used in the Edmond and Ohio Projects. In the Edmond Project, translating services were contracted from Sangamo Weston Corporation, the metering equipment vendor. Meter tapes were collected by tape changer/meter readers, then sent to Sangamo. They were "read" by Sangamo, and sent to the University of Oklahoma for processing and bill preparation.⁴ Dayton Power and Light contracted translation to an outside company for two

¹Telephone interview, Richard E. James, Wisconsin Public Service Corporation, April, 1980.

²Telephone interview, Paul Hart, Arizona Public Service Co., April, 1980.

³Telephone interview, Billy J. Yarborough, Carolina Power and Light Co., April, 1980..

⁴Telephone interview, Neil Dikeman and Marge Early, University of Oklahoma, April, 1980.

months, until it completed its own software.⁵ Another participant in the Ohio Project, Buckeye Power, contracted with Motorola for programming and other software services.⁶

In summary, the Projects used three distinct procedures for acquiring equipment to process TOU billing data: purchase of new equipment, use of existing in-house equipment, and writing outside contracts for service.

BILLING AND METERING

TOU billing requires technical changes in the billing process, and the organizational structure itself may also need changing. The internal organizational structures of utilities vary in many details. One of these variances involves the break between the metering department and the billing (or customer accounts) department. The point where metering ends and billing begins may change because of the implementation of TOU. With traditional rates, meter reading is done by the metering department, and the reading is then channeled to the billing department, which prepares the bill. However, with TOU rates additional steps may be necessary. If magnetic tape meters are used, for example, the tapes will have to be translated, edited and verified. Without translation the data remain incomprehensible. It is the translator that "reads the meter." This raises the issue of where this step (translation) belongs--in metering or in billing. Some utilities have included it in one place, some in the other.

Another relationship between metering and billing involves data requirements. In order to prepare an accurate bill, accurate meter readings are required. With single dial kwh meters, inaccurate data can come from faulty meters, sabotage, or reading errors. Reading error, while a problem, can be easily corrected by taking a new reading or by waiting until the next reading for an adjustment. In fact, most reading errors are self-correcting

⁵Ohio Demonstration Project Progress Report, May, 1977.

⁶Ibid.

with subsequent readings.⁷ But some TOU meters make it possible to lose all or part of a record with no chance to replace or subsequently correct it.

Operationally, TOU rate structures require that not only the amount of consumption but also the time of that consumption be available and reliable. In order to assure this, new billing routines must be arranged.

BILLING DATA PROCESSING⁸

To collect data with multiregister watthour metering, each dial is read and its registered value is entered on the appropriate form, along with the required accessory data (customer account identification, meter identification, date, etc.). With magnetic tape metering, the corresponding operation is the removal of the tape cartridge or cassette from the recording meter and similar accessory data is attached to the cartridge. But the accessory data must include the tape exchange time to the minute, a total kilowatt hour consumption reading taken from the dial of the pulse initiating meter, and an identifying number for the tape.

Multiregister meter data, while still on the meter reader's forms, are checked against the customer's past record for unusual deviations from normal consumption. Problematic readings are returned to the field (typically to the supervisor of meter readers) for validation, such as re-reading the meter, looking for evidence of malfunction, or looking for time errors induced by power outage. Readings not returned for validation are then keypunched if bill computation is computerized, or tabulated in a manual procedure.

⁷This is especially true if the reader is well trained. An error from one reading is caught and adjusted with the next one. There are cases in which a reader continually neglects to read the last dial of a meter. However, most of these are eventually detected.

⁸This overview is based on the documentation of several of the Projects. Citations of particular documents are reserved for the reviews, below, of specific aspects of the billing process in individual Projects.

The corresponding phase for magnetic tape meter operations is translation of the meter tape and verification and editing the data. The translation of a meter tape results in another magnetic tape. This second tape (a half-inch computer tape) bears a sequence of numbers, each one the count of data pulses occurring between two time reference pulses. Multiplying each of these numbers by the appropriate meter constant and pulse multiplier converts these data into a time record of energy consumption. This provides the basis for determining total consumption in each tariff period and, where appropriate, various categories of maximum demand. During translation itself, or in a separate procedure immediately following it, the data are automatically scrutinized for various indications of invalidity, and these are "flagged," i.e., signalled on the computer tape where they occur. Typical flags indicate such problems as missing time-reference pulses, mismatches between the total kwh consumption taken from the meter dial and that computed from the tape, discrepancies between the service time of the tape as logged by the meter reader and as computed from the number of time-reference pulses, improbably large or small total consumption, or improbably high peak demand. Billing editors attempt to account for and rectify these indicated problems. Various corrections can be performed on the data at this stage (e.g., eliminating time or consumption mismatches, deleting or otherwise modifying extreme demand peaks): this constitutes the editing process. Often this stage of bill production consists of a recurring cycle between validity checks and editing procedures. In some cases the data are shuttled between two departments, one checking data quality and the other correcting the errors found by the first, until the customer's record meets the qualifications for bill computation.

Sometimes magnetic tape data cannot be thus repaired: data pulses may be missing throughout the length of the tape, or a meter failure may have left a short period of consumption recorded. In such cases, the utility must estimate the bill. In the majority of these instances, total kwh consumption is known since magnetic tape meter failure usually occurs in the recording

components rather than in the watthour meter proper. The estimation problem typically allocates total consumption to the different tariff periods. A corresponding problem can arise in multiregister metering when time controls fail and all consumption accumulates on one register. In general, estimates are statistical extrapolations of past consumption patterns. If enough of the present record is intact, the consumption pattern can be extrapolated to fill in the rest of the record.

Billing operations do not need perfectly "clean" data from the tape. Usually there are small tolerances in the major aspects of data validation, within which discrepancies are ignored. When all relevant data are corrected to these tolerances, bills can be computed.

For the most part, the remaining steps after data "cleaning" are thoroughly routinized or arithmetical in character, and exhibit no qualitative departure from the traditional practices of non-TOU billing. Complications arising in these stages usually result from human errors in execution or in planning. A major exception involves checks of billing accuracy which are performed after bill computation. In this process machine error is more likely than human error.

Some Projects carried out these checks on every experimental bill computed; others checked samples from each billing period's production in a sort of quality control audit. In either event, this step often replicated the validation and editing procedures applied before bill computation.

BILLING AND CUSTOMER RELATIONS

Each Project made special provisions for handling customer relations. Most of the arrangements served two purposes: 1) answering customer inquiries about various aspects of the TOU experiments and 2) dealing with customer complaints and questions about their bills. These two were aspects of the same program, but in this report only those that are specifically billing-related will be examined. The latter will be taken up in the report on Information to Customers.

While each Project had unique elements in its customer relations programs, one of two general methods was typical. In some Projects the task was assigned primarily to the Customer Service or Customer Relations Department, as in Arizona, Arkansas, North Carolina and Los Angeles. The Projects usually held half-day training sessions with the customer service personnel to instruct them on the experiment and what it was about. For example, in the Arizona Project ten or twelve Marketing Department personnel were trained to explain bill computations to customers. At first they worked from hard copy, but later, computer terminals were used to allow quick access to customer files, since hard copy was too slow. The data for TOU customer's peak, shoulder, and off-peak demand took up more space than a non-TOU customer's data; thus computer storage was preferred because of its quick access, and it was easier to assimilate diverse records at the terminal.⁹

In the Arizona Project the bills were prepared by hand. A customer's bill was first computed by the regular billing procedure using the regular rate. It was then sent to the Project staff who, using a pre-set worksheet, calculated the bill in parts (TOU rates). The bill and the worksheet were then sent to the customer. This was done so that the customer could see all steps of the computation. If questions arose about the bill the marketing people further explained the computations. However, there were few complaints in Arizona. There was a higher than normal level of inquiries at first, but most of these involved things customers had been told and had forgotten.¹⁰

Another procedure used in some of the Projects (Vermont, Rhode Island, Los Angeles, and Connecticut) was to give customers on TOU rates a special phone number to call if they had inquiries or problems. In North Carolina, if the callers identified themselves as being on TOU rates the call was forwarded to the assigned representatives. Calls came into the regional office, but office

⁹Telephone interview, Paul Hart, Arizona Public Service Co., April, 1980.

¹⁰Ibid.

personnel were instructed not to inform customers on TOU rate questions. Callers who did not identify themselves as TOU rate customers were also referred to a specially trained representative. Customers who were not satisfied with the answer or explanation were referred to the utility's general office or to a commission staff member, whichever the customer preferred.¹¹

A variant of this procedure was to route customer calls to a specially designated person. In Rhode Island, calls to the utility were referred to the Project manager, who was also the manager of rates. He had access to the customer's bills and billing history and was usually able to answer the questions.

In Connecticut a member of the commission staff answered questions on bills. In a few cases (about five per year) this staff member called specific customers to tell them that their bills had been estimated and to explain, if necessary, how they were estimated.¹²

In most of the Projects, inquiries and complaints were handled at the local or regional offices. If a problem remained, it was passed along to a higher level. Perhaps the extreme case was in the Wisconsin Project where several Project personnel were kept busy for nearly three months with a few persistent customers who were unhappy with the TOU rates.¹³ It is not clear that these were billing problems but they were billing related, and Project personnel were asked to watch closely for evidence of severe hardship due to TOU rate changes.¹⁴ Besides these persistent customers, there was an increase in the number of calls at the beginning of the Project, but the increase was not enough to burden the existing customer relations staff.

¹¹Telephone interview, Billy J. Yarborough, Carolina Power and Light Co., April, 1980.

¹²Telephone interview, Jackalyne Pfannenstiel (Smith), California Public Utility Commission; formerly, Connecticut PUC.

¹³Wisconsin Demonstration Project Progress Report, July, 1977.

¹⁴Ibid.

Most of the Projects experienced this increase in the number of calls at the beginning of the Project. The number then tapered off as the Project continued. Most of the Projects kept track of the number and subject of the phone calls. Some Projects even kept logs of the calls. These data give a picture of customers' concerns. For example, in Connecticut, 193 calls were received during the Project. The breakdown by subject of call was: week-end rates, 23; change to Eastern Standard Time, 17; appliance purchase program, 20; power outages, 15; a hurricane which had recently occurred, 9; continuation of the test, 10; general information, 58; and billing, 41. Of the 41 billing-related calls, 10 occurred in November, the fourth month of the test, 6 in December, 6 in January, 5 in February, 5 in March, 3 in April, 1 in September, 2 in November and 2 in December.¹⁵

Many callers asked for information or explanation. In North Carolina one of the participating utilities, Carolina Power and Light, found that customer calls on bill complaints led to the discovery of some undetected errors.¹⁶ The same thing happened in the Vermont Project. Most calls were requests for information and were not challenges to the bill. However, the customer representatives were provided with a billing history of the experimental customers having complaints. Anything not resolved at that level was routed to the Customer Accounting Supervisor of the participating utility.¹⁷

The bill was, of course, a source of information to customers, and their response to the new rates depended upon the degree of detail in the bill. Some of the bills rendered to customers were quite extensive, with different rate period charges printed separately. Some Projects also printed a message on the bill, indicating that such and such a shift in consumption would reduce

¹⁵Connecticut Demonstration Project Final Report, May, 1977.

¹⁶Telephone interview, Billy J. Yarborough, Carolina Power and Light Co., April, 1980.

¹⁷Telephone interview, John Keene, Green Mountain Power Corp., April, 1980.

the bill by so much. Sometimes the bill contained a list of consumption by time period, and a list of how much electricity was used by specific appliances. In order to add this increased specificity to the bill, additional data had to be gathered and processed, which complicated both gathering consumption data (metering) and processing that data (billing).

SUMMARY

Of course, billing practices are not uniform among utilities, and this is as true for the Projects as it is for non-experimental operations. Billing with TOU rates required some changes in equipment, data processing, customer information and personnel training. The Demonstration Projects addressed these changes in a number of different ways. The utilities involved in the Projects sought to accomplish different ancillary goals in the course of billing, and they pursued similar billing goals through different means. Some problems and responses to problems were unique to particular Projects. In the remaining chapters some of these special features and problems are reviewed. Also examined are more general aspects of the billing process.

CHAPTER :
THREE : BILLING EQUIPMENT
:

INTRODUCTION

This chapter examines the billing equipment used in the Projects. The discussion covers both hardware and software. Each section includes a discussion of the capability of the equipment, its cost, and problems and solutions. Examples are given of the specifications required for both hardware and software.

Most of the projects had to acquire new billing equipment or alter their existing equipment. In the process of acquiring and changing the equipment a number of problems arose, some of which are addressed in this chapter. The amount and degree of sophistication of the equipment varied from project to project, depending upon system needs and existing equipment capability. This had a significant impact upon cost and the emergence of problems.

HARDWARE

The type of billing hardware used depended upon the type of meters used. In the Projects that used only multiregister meters no additional hardware was purchased.¹ On the other hand, those using magnetic tape meters required a translator and usually a minicomputer. Table 1 shows some of the Projects that used translators and minicomputers.

A translator interprets the data pulses, counts the number of pulses and, in effect, "reads" the meter, by converting the energy pulses into computer readable code. Translators vary in capability. Some merely count pulses, while others verify tape data. A verifier is optional and can be purchased along with the translator. Wisconsin Public Service was the only utility

¹It might be noted that two programmable typewriters were purchased for processing the elaborate "extra information" bills in the Washington Project.

which purchased a translator with a built-in verifier. A verifier is a piece of hardware which reads and packs both time and data pulses onto a tape and then reads them back to find out if any pulses are missing. If fewer pulses are read out than recorded, problems such as an oxide defect or holes in the tape are likely.²

Typically, the minicomputer was used to edit the data. Data were put onto random-access disks along with customer account information. While the data were recorded on the disk, adjustments and corrections could be made. The edited data were then put back onto (one-half inch) computer magnetic tape and read into the main computer. The mainframe computer usually contained a program which generated TOU bills and other TOU billing documents--such as hard-copy--for customer representatives. Typically, the translator and minicomputer were tied together by a software program which also interfaced with the mainframe computer.

Both the translation and the editing hardware were usually purchased as a package. The specifications for vendor bids typically contained a description of the capabilities of the "translation system." The specifications described a system for reading, analyzing and editing meter tape data. Software capability was usually included in the specifications. An example of the detailed specification for a translation contract system, from the contract specifications of the GRDA Project, is shown here:

1. TAPE READER SYSTEM

- (a) Tape cartridge reader system must be capable of accurately reading cartridges recorded on Westinghouse, Duncan, General Electric and Sangamo recorders. The tape speed should not be less than 30 inches per second in both the "Read" and "Rewind" direction. The tape transport shall be equipped with five clearly defined panel controls marked "Stop," "Forward," "Reverse," "Translate," and "Manual."
- (b) The tape reader shall have the necessary input control channels to permit the minicomputer to automatically

²Telephone interview, Richard E. James, Wisconsin Public Service Corp., April, 1980.

start the reader after the system has detected the minimum amount of data necessary to translation.

- (c) The manufacturer shall detail the recommended minimum set of spare parts for all equipment supplied and their cost.

2. INTERFACE REQUIREMENTS

- (a) The tape transport shall be linked directly to the minicomputer through an interface that contains a programmable clock or time base generator and the necessary gates and buffers to allow for blanking circuits between time pulses, accurate timing pulse insertion (with no data skew) and false time pulse detection.
- (b) The minicomputer should appear as a terminal for interfacing with a Wang 2200T computer.
- (c) The operator must have the capability of selecting which interface is to be used and also have the option of selecting pertinent billing information that is stored on the half inch translator magnetic tape and transmitting such information to the Wang 2000T computer.

3. HARDWARE

- (a) The translator computer system shall be equipped with a programmable digital computer (Hewlett-Packard Model 21MX) or equal. This minicomputer should be able to complete a two pass, disk buffered, batch oriented translation and real time executive (RTE III) multi-programming system. The following equipment (or equal) should be incorporated in the minicomputer.
 - 1. Hewlett-Packard 2113A CPU
 - 2. Hewlett-Packard 2102B CPU Memory System
 - 3. Hewlett-Packard 13187A-16K Memory (4 required)
 - 4. Hewlett-Packard 12991A Power Fail Recovery System
 - 5. Hewlett-Packard 12897A Dual Channel Port Controller
 - 6. Hewlett-Packard 12539C Time Based Generator (2 required)
 - 7. Hewlett-Packard 12936A Privileged Interrupt Fence
 - 8. Hewlett-Packard 12962C 15 Megabyte Cartridge Disk
- (b) OPERATOR'S CONSOLE

The translator computer system shall be equipped with a CRT terminal (Hewlett-Packard 2640B CRT terminal) or equal.
- (c) HIGH SPEED PRINTER

The system shall contain a high speed printer (Hewlett-Packard 12987A, 200 lines per minute, 132 columns, matrix impact printer) or equal.
- (d) MAGNETIC TAPE SYSTEM

The system shall contain a nine channel 1600 BPI magnetic tape drive with read-after-write capability. (Hewlett-Packard 12972A-45 IPS) or equal.

(e) CARTRIDGE READER

The system shall contain a quarter inch magnetic tape cartridge feeder capable of reading Duncan and Westinghouse cartridges (DEPCO MTR-45-TC cartridge reader) or equal. The tape speed shall not be less than 30 inches per second in both the "Read" and "Rewind" directions.

(f) PAPER TAPE READER

The system shall contain a paper tape reader for reinitializing the system (HP 12925A 500 CPS. Paper Tape Reader) or equal.

4. INTERCONNECTING WIRING

- (a) The vendor shall provide all interconnection cables and devices necessary for permanent assembly.

Figure 1 shows the main components of GRDA's translation system. It includes a cartridge reader, clock and interrupt, minicomputer, high speed printer and CRT. The minicomputer was designed to output data onto both a 15 megabyte disk and a 9-channel magnetic tape. This system operated on its own, but eventually it was to be connected to another minicomputer system for computer output of TOU bills.³

Cost of Billing Hardware

The data on hardware cost are rather limited. Only three Projects reported costs on translators and two reported costs on mini-computers. Most of the utilities either already owned a translator, did not require one for the Project, or contracted for translation.

The costs reported for translators were \$35-40,000 in Arkansas, \$50,000 in Los Angeles and \$19,000 in Wisconsin. The costs reported for minicomputers were \$25,000 in Los Angeles and \$21,000 in Wisconsin.⁴

Two Projects reported costs of the translation system. North Carolina reported a cost of approximately \$130,000 for the Carolina Power and Light translation system. This included a Westinghouse

³Telephone interview, Peter Whiting, GRDA (formerly), August, 1980.

⁴See Table 1 footnotes for sources.

Figure 1

GRDA's Translation System Hardware

TABLE 1

Billing Equipment Used During the
Electric Utility Demonstration Projects, by Project

Project	Translator		Minicomputer		Equipment ^b Status
	Mfg. and ^a Type	Cost	Mfg. and ^a Type	Cost	
Arkansas ^c	(W)	\$35-40K	-	-	P
Connecticut ^d	(W) WLT-30A	-	-	-	-
Edmond ^e	(S)	-	-	-	C
GRDA ^f	(S)	\$90,845 ^g	(HP)	-	P
Los Angeles ^h	(S)	\$50K	(HP)	\$25K	P
North Carolina ⁱ	(W) WLT-40	\$130K ^j	(HP)	-	A
Puerto Rico ^k	(W) WLT-26	-	(IBM) 44 digital	-	P
Rhode Island ^l	(S)	-	(HP)	-	P
Wisconsin ^m	(D)	\$19K	(IBM) Sys. 7	\$21K	P

Source: Compiled from Electric Utility Demonstration Project documents and reports and interviews, 1975-1980. Specific documents are denoted by footnotes below.

a Letters in parentheses indicate the manufacturer:

W=Westinghouse

S=Sangamo

HP=Hewlett-Packard

IBM=International Business Machines

D=Duncan

b Equipment status relates to how the Project accessed equipment. There were three ways: P=Purchased for the Project; A=Already owned before start of Project; C=Contracted with a vendor for use.

(continued)

TABLE 1

(continued)

- c Telephone interview, David Bryant, Arkansas Power and Light Co., April, 1980.
- d Connecticut Demonstration Project Final Report, May, 1977.
- e Telephone interview, Neil Dikeman, University of Oklahoma, April, 1980.
- f Grand River Dam Authority Pilot Project, memo to C. R. Huddleston from Peter Whiting, November 30, 1977.
- g This is the total for both the translator and minicomputer, as well as some software and ancillary equipment for the translation system. It does not include the cost of the maintenance contract.
- h Telephone interview, Dennis Whitney, Los Angeles Department of Water and Power, April, 1980.
- i Telephone interview, Billy Yarborough, Carolina Power and Light Co., April, 1980.
- j This is the total for both the translator and minicomputer. It also includes some ancillary equipment, such as CRT terminals.
- k Puerto Rico Demonstration Project Procedures of Collection, Translating and Editing of Field Data. (no date)
- l Telephone interview, Lewis Bailey, Blackstone Valley Electric Co., April, 1980.
- m Telephone interview, Richard James, Wisconsin Public Service Corp., April, 1980.

WLT-40 translator, two high speed disks, a Hewlett-Packard mini-computer, a CRT terminal and a teletype terminal. A verifier was not included.⁵

The Grand River Dam Authority (GRDA) reported a total cost of \$104,389 for its translation system. This included a Sangamo translator, a Hewlett-Packard minicomputer, a software system to integrate the hardware and one year of maintenance on the mini-computer (cost \$5,844). Another vendor's bid was about \$500 less but it would have taken ten to twelve months to deliver the equipment.⁶

Problems

Only one of the Projects reported a delay in the delivery of translation equipment. In the GRDA Project the vendor was six months late in delivering the translator, minicomputer and associated software. One reason given by the vendor was that very bad weather delayed programming the computer.⁷

There were fewer operational problems with most of the billing hardware than with the metering equipment. However, there were some problems which indicate what might be in store for those preparing for TOU billing.

Significant problems occurred in Projects where the translator broke down or was not functioning properly. For example, in the Puerto Rico Project the tape translator was not functioning during June through September of 1978. As a result, bills had to be calculated in different ways; most were estimated. About 21 percent of the bills prepared during this period had errors.⁸ The Wisconsin Project experienced some data losses

⁵Telephone interview, Billy J. Yarborough, Carolina Power and Light Co., April, 1980.

⁶GRDA System Improvements Contract 549, 1977, pp. 4-5.

⁷GRDA Pilot Project Progress Report, June, 1977.

⁸Puerto Rico Demonstration Project Progress Report, October, 1978.

because the translator was not able to handle the volume of meter tapes. It was not reported how this problem was resolved.⁹

The Arkansas Project did not experience a complete translator breakdown, but the playback heads on the translator wore out rapidly and had to be replaced. This caused some minor delays in translating tapes. It was discovered that there was an abrasive material on the magnetic meter tape. These tapes were replaced and the problem did not recur.¹⁰

In the Wisconsin Project there were some problems with read heads and capstans on the translator. These occurred because the operators were not informed on routine maintenance procedures. The vendor helped solve these problems by sending a complete manual and by training one of the utility's personnel. There was monthly contact with the vendor for some time after the translator was put into operation. This, too, helped solve some routine operational problems.

It took about one year to shake down the translation, verification and billing software in the Wisconsin Project. Fortunately, this was during the period when baseline data were being gathered and TOU bills did not have to be delivered.¹¹

GRDA and Los Angeles reported the only problems with the minicomputers. In Los Angeles there was a problem with the tape drive. The vendor was able to solve the problem after two service calls.¹² In the GRDA Project the minicomputer malfunctioned because of excessive temperature and humidity in the operations room. A small air conditioner was relocated to solve the problem.¹³

⁹Telephone interview, Richard E. James, Wisconsin Public Service Corp., April, 1980.

¹⁰Telephone interview, David Bryant, Arkansas Power and Light Co., April, 1980.

¹¹Telephone interview, Richard E. James, Wisconsin Public Service Corp., April, 1980.

¹²Telephone interview, Dennis Whitney, Los Angeles Department of Water and Power, April, 1980.

¹³GRDA Pilot Project Progress Report, 1979.

SOFTWARE

The computer programs used to calculate customer bills varied in capability. There were routines to edit, simulate and analyze data, and routines to calculate kwh usage by time period.¹⁴ A primary function of the software was to interface TOU customers' accounts with the main accounting system of the utility. In most of the Projects that used magnetic tape meters there were two software packages, or two routines in one package: one (which tied the translator to the minicomputer) was used for editing and analyzing metered data; and the other (for the mainframe computer) was used for computing bills and keeping track of customer accounts.

In some of the Projects the software was developed "in-house" by the participating utility. In others, such as North Carolina, a package was purchased from a vendor. One of the participating utilities, Carolina Power and Light (CP&L), owned a translation system but it was augmented by another for the Project. When the first system was purchased the specifications were not detailed and computer personnel were not involved. The vendor explained the capabilities of the translator programs and CP&L tried to determine if they were adequate. However, the explanation was not thorough enough, and some inadequacies were discovered after the translator was installed. Additional software was needed to tie the translator to the mainframe computer.

When the second system was ordered, computer personnel assisted in writing the specifications. Since CP&L already had a system and did not want to change it, the software for the second system had to be designed for the existing system. The vendor did this and there were no reported problems with the software for the second system. The actual bills for the TOU customers were prepared on the mainframe and the software was done "in house." Only one problem with the mainframe program was reported; a failure to account for seasonal rate changes. This was caused by the month

¹⁴Chapter 5 examines the specifics of some of the Projects' data processing routines.

to month counting method used and the fact that the month used to test the program did not contain a seasonal rate change. This was overlooked for fifteen billing cycles, until customer calls brought the problem to the utility's attention.¹⁵

Another Project which purchased software was GRDA. In that Project considerable care was exercised in specifying the software. In order to learn what was necessary for a properly functioning translation system, one of the Project personnel with a degree in computer programming and electrical engineering did a survey of the translation equipment vendors. He also talked to vendor sales personnel and a nearby utility which had a translator in operation. This information provided detailed specifications for software.¹⁶ These specifications are summarized below in Table 2 (the complete specifications are listed in Appendix 1). Even though detailed specifications were given in the contract, a GRDA representative visited the vendor before the bid was accepted to examine the proposed equipment and to talk with vendor representatives. When the contract was let, a GRDA representative again visited the vendor to study hardware and software routines. Once the equipment was installed, the vendor made a three to four day field visit to train the GRDA personnel who were to operate the system.¹⁷ There were no major problems with the software, but a few minor problems occurred when the software was adjusted to accommodate GRDA data codes. Fortunately, the vendor was able to fix these problems in a very short time.

It is important to note that the GRDA software as purchased from the vendor was incapable of performing TOU billing. Before the TOU billing routine was designed bills were calculated by pulling data off the translation system, and keypunching it into another minicomputer. It took GRDA personnel approximately 100

¹⁵Telephone interview, Billy J. Yarborough, Carolina Power and Light Co., April, 1980.

¹⁶Telephone interview, Peter Whiting, GRDA (formerly), August, 1980.

¹⁷Ibid.

TABLE 2

Software Capability and Specifications, Grand River Dam
Authority Pilot Implementation Project

Capability	Specification
1. Validity Check	Check field tapes for validity.
2. Time Interval Check	Calculate correct number of time intervals on field tape.
3. Data Check	Compare KWH and KVARH totals in each channel to actual meter readings.
4. Input of Data	Fixed data stored in disk and accessible via console--capable of being changed when fixed data changes.
5. Outage Insertion	Insert up to six outages per tape.
6. Concurrent Data Entry	After entry of field tape data, read tapes and enter variable information simultaneously.
7. False Pulse Detection	Count but not dump the count when pulses are found in blanking period. Flag false pulses on output.
8. Missing Interval Pulse Insertion	Insert and flag missing pulse when validated demand data are in existing interval channels.
9. Recovery Routine	Recover as much data as possible when pulses are missing or skewed out of place.
10. Recorder Intervals	Translation of tapes 5, 15, 30 or 60 minute intervals, from 16, 36, and 72 days duration.
11. Dump Program	Produce interval by interval pulse listing for one or more field tapes.
12. KWH and KVA Peak	Produce totalized KWH and the 3 highest values of KW, KVA and coincident KVA and KW values.

continued

TABLE 2
(continued)

Capability	Specification
13. Completion Report	Identify tape cartridge, date time translated, print a comparison of meter readings, number of translated pulses, faults, inserted pulses, etc.
14. Daily Summary Program	Output KW, KVA, pf, volts, amps for a particular day: the high, low and average value for each calendar day.
15. Status List	Process must be able to respond at any time to request for translation done and yet to be done.
16. Error Message Output	A high priority program for output errors and give operator immediate feedback as to problems.
17. Daylight Savings Time	Two changeovers per year carried on file to add or subtract an hour from date, but not change file data.
18. Leap Year	Must recognize leap year and adjust its calendar.
19. Purging the System	Must be able to purge a translation at any time.
20. Smaller Time Interval Translation Program	Must study customer's usage during smaller increments than those recorded on field tape.
21. Rolling Peak Optional Program	Program allowed to add shorter intervals to get extended intervals that overlap-print out results during translation.
22. Multiple Meter Programs	Must accept multiple meter tapes for the same customer and provide sum of all net readings.
23. Totalizing Program	Should be able to total all translated tape for a particular interval.

continued

TABLE 2
(continued)

Capability	Specification
24. Coincident Peak Program	Be able to find coincident peak from a set of 200 or 500 metering installation tapes.
25. Calendar Month Program	Carry over of partial information from a previously translated cartridge and use an initialization and cut off date to put cartridge tape date into calendar month file.
26. Software Maintenance	Vendor provide one year maintenance contract from date of installation.
27. Voltage	Printout voltage for a particular time of day which would be obtained from the volt squared hour meter on one of the magnetic tape tracts.

Source: GRDA System Improvements Contract 549, 1977.

a See Appendix 1 for the complete specifications of this software.

manhours to design the additional program for TOU billing. This program was capable of showing the kw and kwh usage for each customer. It incorporated adjustments for holidays, daylight savings times and season changes. Further, it found the coincident peak, adjusted for line losses and therefore was able to show the total system load.¹⁸

Although hand billing was used in Rhode Island, a translation software package was purchased for about \$3,400.¹⁹ This package was capable of reporting, on an interval by interval basis, the three highest peaks in terms of kwh's; thus providing a billing analysis for peak/off-peak kwh, kw usage, and monthly kw peak demand. No bugs in the program were reported, and no system adjustments were necessary to integrate it into the system.²⁰

In Ohio, Dayton Power and Light purchased software for their magnetic tape meter data. The program did not process the bill, only the data required for it. It also edited and cleaned the data. A particularly difficult problem was that the program picked up a number of "bad zeros." That is, the record would indicate no consumption when, in fact, there was. Re-programming was required to solve the problem.²¹

In the Edmond Project, data processing for TOU customers was contracted to the University of Oklahoma, Bureau of Business and Economic Research. The meter tapes were sent to Sangamo Weston Corporation for translation and then to the University for editing and analyzing. The Bureau required about two months to write the program and two months to debug and test it. The program was designed to aggregate peak and off-peak consumption, apply the appropriate rate to each

¹⁸Ibid.

¹⁹Telephone interview, Lewis Bailey, Blackstone Valley Electric Co., April 1980.

²⁰Ibid.

²¹Ohio Demonstration Project Progress Report, September, 1977.

period, and add these rates to yield the total amount of consumption for each customer. There was a sub-routine dealing with TOU and seasonal rate data, another for messages printed on the bill and one for determining if there were late payments. Most of the problems with the programs turned out to be due to meter reading and tape changeout errors. Once these problems were solved, the programs ran fairly smoothly.²²

Some of the Projects that developed software in-house were Arkansas, Los Angeles, Puerto Rico and Wisconsin. In Arkansas, the participating utility developed its own billing software. This required about one month for a full-time programmer. The meter tapes were translated and sent to a central computer system located at Middle South Utilities in New Orleans for editing and verification.²³

The Wisconsin Project exemplifies the in-house development of a complete software system. In that Project, one and one-half man-years of senior programming time were devoted to writing and debugging the programs. One of the significant problems encountered was the difficulty of writing the real time programs necessary for translator control. This problem occurred because the tape was moving when the signal pulses were recorded and read back. This required various buffers and was a difficult problem to solve. Another problem surfaced when tapes were run through the translator once, the program altered (which does not affect translation) and the tape rerun. When this was done, the results varied. For example, on the two runs the kwh total might have been the same but the fifteen minute groupings of data were different. In Wisconsin, these sorts of problems took significant amounts of time to solve, but they were likely problems since the translation program was written from scratch. According to one

²²Telephone interview, Neil Dikeman and Marge Early, University of Oklahoma, April, 1980.

²³Telephone interview, David Bryant, Arkansas Power and Light Co., April, 1980.

Project representative this is one reason why utilities buy software packages instead of writing them in-house, but such problems can also exist in the ones they buy.²⁴

In the Wisconsin Project, the software interfaced with a minicomputer (IBM System 7). The translation system read the tape data and time channels. The minicomputer had controls for use if a channel failed. The program supplied pulse multipliers to convert pulses into energy counts and a meter constant to assign the correct magnitude to the energy units. It grouped data by fifteen minute intervals and performed a first stage match-check times match. The program did not edit data but did flag mismatches, missing data or other anomalies. The verified and flagged data were then loaded onto a disk so that an editor could review them. No customer records were altered until they were on the disk and the meter tape was not erased until it was cleared by the editor.²⁵

Cost of Billing Software

Only two Projects submitted direct cost data for software-- GRDA and Edmond, Oklahoma. In the GRDA Project, the cost was part of the total bid for the translation system. However, a reasonable estimate of software was made by subtracting an estimated cost for hardware. It was estimated that the software cost about \$28,000.²⁶

In Edmond, the cost of writing programs, including the billing program, was estimated at \$20,000. This was arrived at by taking the sum of programmer's salaries times the proportion of their time spent on project software.²⁷

²⁴Telephone interview, Richard E. James, Wisconsin Public Service Corp., April, 1980.

²⁵Ibid.

²⁶Telephone interview, Peter Whiting, GRDA (formerly), August, 1980.

²⁷Telephone interview, Neil Dikeman and Marge Early, University of Oklahoma, April, 1980.

SUMMARY

Translation systems were the most important change required in the billing equipment of most utilities when magnetic tape meters are used. This system usually involved a tape reader, minicomputer and software to interface the two and deliver specific printouts. The total cost of such a system depended primarily upon the sophistication of the software. The translator systems used in the Projects ranged from about \$50,000 to \$100,000.

Most of the problems with translation systems revolved around two areas: 1) metering tape problems and 2) software inadequacies. Some Projects had tape translation problems because the tapes were defective and improperly recorded data. Others had problems with tapes containing abrasive substances which wore out the recording heads on the translator, while some had problems because tapes had been improperly changed or meters improperly read.

Software or programming problems were common to most of the projects. Sometimes vendors were unable to meet exact specifications, or the Project was unable to foresee all the changes which would be entailed in producing a bill from magnetic tape data. A significant problem was that of real time vs. meter time. Solutions involved the use of various buffers to adjust for tape speed inconsistencies. Another software problem involved having sufficient capability to handle data errors, improper time pulses, and data mismatches. These problems resulted in the use of many hours of programmers' time and might cause delays in future work if not anticipated and planned for. In the next two chapters a number of specific data and bill processing problems are discussed.

CHAPTER :
FOUR : COMPONENTS AND DATA REQUIREMENTS OF TOU BILLS
:

INTRODUCTION

This chapter examines several kinds of bills rendered to TOU customers during the Projects. It includes a survey of typical TOU bills from the simplest to the more complex, as well as a close look at the types of data necessary to produce these bills. Additionally, some of the problems encountered in developing the bills and the attendant data are discussed.

It is important to examine these experiences because they provide insights into what modifications may be required for producing a TOU bill. TOU pricing of electricity will normally involve a more complex bill, with more extensive data requirements, than standard pricing schemes. The number of additional bill components can vary considerably, depending on the rate structure and the amount and kind of extra information the utility transmits. The bill designs of the Projects show many of the possible variations. It might be possible for the total amount due to serve as a price signal for shifting consumption away from peak periods. However this type of signal mixes total consumption with the time of consumption, leaving customers without a direct way of knowing how much electricity they used during peak or off-peak times. The price signal function of the bill was better served by an indication of the energy consumed in each tariff period and the price during each period.

"MINIMAL" TOU BILLING IN THE PROJECTS

The simplest TOU bill has many of the same components as the typical non-TOU bill, i.e., billing period dates, total kilowatt hours consumed during the billing period, the total charge for all kwh's consumed, fuel adjustment factor, customer charge, payment in arrears (if any), taxes, and the total amount due. The only additional items in a minimal TOU bill are the separate totals of kwh's consumed in each tariff period and the charge for that consumption.

A traditional electric bill, with an added itemization of energy consumption into tariff periods, was used in Connecticut, Los Angeles and Puerto Rico. An example from the Connecticut Project illustrates this type of bill. In this Project a typical bill showed the billing dates, the meter reading (previous and present) and the breakdown of charges into peak, normal, and off-peak tariff periods. Kilowatt hour totals were shown for each tariff period, along with the total amount payable for each period, but not the price per kwh. The rate structure itself was listed on the reverse of the bill.¹ Like Connecticut's, the Los Angeles Project bill did not present actual rates for the peak and off-peak periods--only the dollar amounts payable for total kwh's in each period were recorded. Primarily because of limitations in the minicomputer, this was about all the information that the Los Angeles Project could include in its TOU bills. When customers asked about the difference in tariffs they were referred to their copy of the contract covering their participation in the experiment, which showed the rate structure.² The Puerto Rico Project bill was also simple. It displayed only the peak kwh's consumed and the peak energy charge, the off-peak kwh's consumed, an energy charge, and the total amount due.³

ADDITIONAL ITEMIZATION IN TOU BILLS

Complexities of rate structure can lead to significant complications in bill design. If the rate incorporates a demand aspect, it may be desirable to present the customer with a bill showing the day and the time of day when peak demand occurred.⁴ A TOU dimension can be imposed on the demand component as well as

¹Final Report, Connecticut Peak Load Pricing Test, May, 1977.

²Telephone interview, Dennis Whitney, Los Angeles Department of Water and Power, April, 1980.

³Final draft, Consumer Education Brochure, Puerto Rico Demonstration Project.

⁴Telephone interview, John Keene, Green Mountain Power Corporation, May, 1980.

Figure 2

Example Of TOU Billing--Connecticut Demonstration Project

Front Side →

CLP

AMOUNT DUE

ACCOUNT NUMBER _____ DATE _____

RETURN ADDRESS _____ NAME - BILLING ADDRESS _____

RATE XPLP

CLP

SERVICE ADDRESS _____ DATE _____

BILLING PERIOD FROM _____ TO _____ METER READING _____ ACCOUNT NUMBER _____

PERIOD	KILOWATT - HOURS	CHARGE
PEAK		
NORMAL		
OFF PEAK		

FOR YOUR RECORDS

PREVIOUS BALANCE	
PAYMENT	
BALANCE	
CUSTOMER CHARGE	\$ 2.00
TOTAL	

SEE REVERSE SIDE FOR RATE INFORMATION

AMOUNT DUE

Back Side →

"This bill reflects electric service that is charged at a special rate ordered by the Connecticut Public Utilities Commission on June 16, 1975 to apply their Residential Peak Load Pricing Field Test intended to remain in effect for a period of one year commencing on or about October 16, 1975."

SUMMER (MAY 16 - OCT 15)		PERIOD	RATE	WINTER (OCT 16 - MAY 15)	
10 AM - 12 AM	1 PM - 3 PM	PEAK	.18/KWH	9 AM - 11 AM	5 PM - 7 PM
8 AM - 9 PM (EXCEPTING PEAK HOURS)		NORMAL	.09/KWH	8 AM - 9 PM (EXCEPTING PEAK HOURS)	
ALL OTHERS		OFF PEAK	.01/KWH	ALL OTHERS	

* WEEKENDS AND DESIGNATED HOLIDAYS EXCLUDED

Any questions in regard to this bill or this field test may be directed to:

Project Information Officer
Off Peak Pricing Opportunity Office
Public Utilities Commission
State Office Building
Hartford, Connecticut 06115
Telephone: 566-3696

on the energy component of the rate structure. The Rhode Island Project, for example, distinguished between two categories of demand: a distribution charge, applied to the peak demand which occurred at any time during the billing period, and a capacity charge, applied to the highest demand within system peak periods.⁵ In order for this distinction to have the maximum effect on load management, the bill had to indicate when both peaks occurred.

A further complication of bill design arose when fuel cost adjustments were applied to TOU energy charges. If the adjustment was applied to the total kwh's consumed, without regard to tariff period, it augmented or diminished the tariff of each period by the same amount. This in turn caused variations in the effective price ratios among the tariff periods. Since the fuel cost adjustment usually changed from one billing period to the next, its application to total kwh consumption resulted in time-varying price ratios. This variation could be significant under some circumstances. For example, had the fuel cost adjustments for the summer billing months of the Arkansas Project been applied to total kwh consumption, the peak/off-peak price ratio would have varied between 3.54 : 1 and 4.67 : 1, and would never have attained its prescribed value of 6.08 : 1.⁶ To preserve the intended price ratio, the Arkansas Project assigned different fractions of the fuel cost adjustment to both tariff periods. On the other hand, the Rhode Island Project did not.⁷ In this case, the largest prescribed price ratio (peak/off-peak) was 1.83 : 1, the off-peak price was 1.85¢/kwh, and the range of fuel cost adjustments was apparently small. Under these conditions the resulting variation in effective price ratios was considered insignificant.⁸

⁵Telephone interview, Lewis Bailey, Blackstone Valley Electric Company, April, 1980.

⁶Computed from data in Final Report, Arkansas Demand Management Study, no date.

⁷DOE File document: copy of tariff sheet for Blackstone Valley Electric Company Experimental Residential Rate No. 7.

⁸This price ratio computed from data in BVE tariff sheet for Experimental Residential Rate No. 7.

However, with larger prescribed price ratios, higher off-peak prices, and substantial variation in fuel cost adjustments, an unapportioned adjustment had a greater effect on each period's energy charge.⁹

The "minimal" TOU bill used in some of the Projects (as well as some of the more complex bills described below) did not show the per-kilowatt-hour rates for the different tariff periods, only the total energy charge for each period. The inclusion of rates per kwh was more feasible when there was a flat rate within each tariff period (as was the case in most Project rate structures). In the Vermont Project the cost per kwh within each tariff period was a function of kilowatt hours consumed, the peak and off-peak periods differing both in the average level of price and in the relationship between price and consumption.¹⁰ All this might cause a rather cumbersome format if these prices were integrated into the main bill. However, the Vermont Project TOU customers were presented with full tariff information since the format of all the Project's non-traditional bills was essentially the worksheet used during their manual preparation.¹¹ The Arkansas TOU included separate rates per kwh for the two tariff periods as integral parts of the main bill, along with the on-peak consumption, the off-peak consumption, the total energy charge for each period, the customer charge and a price ratio preserving distribution of the fuel cost adjustment over the two tariff periods.¹²

⁹Close maintenance of price ratios may not have mattered in some Projects. The prescribed peak/off-peak price ratio in the Connecticut Project was 16 : 1. At the time of the TOU rate design, a typical fuel cost adjustment was 0.2¢/kwh. There is no evidence that this adjustment was apportioned among tariff periods; if it was not, then the effective price ratio was 13.5 : 1, some 15.6% less than prescribed. (Final Report: Connecticut Peak Load Pricing Test, May 1977 and Northeast Utilities Internal Memorandum: Experimental Peak Load Pricing Billing, no date.)

¹⁰Vermont Demonstration Project Progress Report, May, 1975.

¹¹Telephone interview, John Keene, Green Mountain Power Corporation, May, 1980.

¹²Telephone interview, David Bryant, Arkansas Power and Light Company, April, 1980.

Carolina Power and Light, of the North Carolina Project, also included the rate per kwh for each period, as well as the breakdown of consumption and other customary bill components.¹³ A sample CP&L bill is shown in Figure 3.

ENERGY MANAGEMENT INFORMATION ADDED TO BILLS

One kind of TOU bill used in the Edmond Project, and all TOU bills used in the Wisconsin Project presented the customer with a message about energy cost savings. Examples of these project's bills are shown in Figures 4 and 5. The message on the Edmond bills indicated that either the individual customer or his metering group used x percent of the energy on-peak and informed him that every y kwh shifted to off-peak would save him z dollars.¹⁴ The Wisconsin Project presented even more detailed messages. The TOU bill itself showed the latest and previous meter readings, total kwh's consumed, on-peak consumption, off-peak consumption and the charges for each. A supplement showed (1) the percent of total kwh's consumed on-peak, (2) the percent consumed off-peak, (3) the reduction in energy charge had 5 percent of the total consumption been shifted from on-peak to off-peak, and (4) a comparison of the present month's consumption data with the previous month's data and with the corresponding month's data from the previous year.¹⁵ The addition of this supplement to the standard bill format required Wisconsin Public Service to use envelope billing rather than card billing. They were unable to put this supplementary information on the back of a billing card because that space was required for information about the shift from winter to summer rates and vice versa.¹⁶

¹³North Carolina Demonstration Project Progress Report, February 28, 1977.

¹⁴Edmond Demonstration Project Progress Report, May, 1978.

¹⁵Wisconsin Demonstration Project Product User's Guide, no date.

¹⁶Telephone interview, Richard E. James, Wisconsin Public Service Corporation, April, 1980.

Figure 3
Sample TOU Bill--Carolina Power and Light

CP&L Carolina Power & Light Company ANYPLACE NC 12345 <small>RATE SCHEDULE FURNISHED UPON REQUEST</small>					RETURN THIS STUB WITH PAYMENT TO Carolina Power & Light Company				
CUSTOMER NAME DOE JOHN A					DATE MAILED DEC 28 76				
SERVICE ADDRESS 1 NORTH SOUTH ST					ACCOUNT 999999999999				
<small>METER CONST</small>	<small>KW</small>	<small>METER NO.</small>	<small>RATE</small>	<small>BAL. FORWARD</small>	<small>CR</small>				
1		999999	FEA						
<small>METER READINGS</small>		<small>KWH USED</small>	<small>*</small>	<small>AMOUNT</small>					
<small>PRESENT</small>	<small>PREVIOUS</small>								
01170	00000	1170	EL			36.65			
BILLING DETAIL ATTACHED									
APPROVED FUEL CHARGE						2.08			
DEC 23 7630 129					3873				
<small>DATE METER READ</small>		<small>DAYS</small>	<small>A.G. COST PER DAY</small>	<small>TOTAL DUE</small>					
1		30	129	3873					
<small>SEE REVERSE SIDE FOR BILL CODE EXPLANATION</small>									

SAMPLE

A1A 99
 DOE JOHN A 99
 1 NORTH SOUTH ST 9
 ANYPLACE NC 12345 99

 PLEASE PAY THIS AMOUNT
 3873

CAROLINA POWER & LIGHT COMPANY ANYPLACE NC 12345				DOE JOHN A	
N.C. ELECTRIC UTILITY DEMO. TRU TIME OF DAY BILL ATTACHMENT				1 NORTH SOUTH ST.	
RATE: R-FEA-1b ACCOUNT: 999999999999				ANYPLACE NC 12345	
	<small>KWH USED</small>	<small>PRICE PER KWH</small>	<small>ELECTRIC SERVICE AMT</small>	<small>APPROVED FUEL CHG</small>	
BASIC CUSTOMER CHARGE			6.00		
ON PEAK PERIOD		450 .01840	8.28	.90	
OFF PEAK PERIOD		720 .01520	10.94	1.18	
ON PEAK DEMAND		9.00 KW @ 1.27	11.43		
OCCURRED AT		6:30PM DEC 18 1976			
SERVICE TO DEC 23 1976		TOTALS	36.65	2.08	

SAMPLE

Figure 4
Sample TOU Bill--City of Edmond

PLEASE REMIT TO: CITY OF EDMOND 23 E. FIRST EDMOND, OKLA. 73034						FIRST CLASS MAIL U. S. POSTAGE PAID 1 OZ. PERMIT NO. 69	
DAY-TO-DATE METER-741-0452 ACCOUNT NUMBER 3490-1 SERVICE-ADDRESS 419 W. HURD						RETURN POSTAGE GUARANTEED	
PRESENT	PREVIOUS	CONSUMPTION	CODES	AMOUNT			
3022	2604	418	EL	7.94	OFF		
3166	2852	314	EL	19.88	PEAK		
FIXED FEE			EL	6.00			
			PB	37.86			
					CELL 9		
YOU USED 42% ON-PEAK. EVERY 100 KWH SHIFTED SAVES \$4.20							
(FOR PROPER CREDIT, PLEASE RETURN THIS SLIP WITH PAYMENT)							
PB - PAST DUE BILL		SR - SEWER		EL - ELECTRIC		ACCOUNT NUMBER - 3490-1	
QA - GARBAGE		SL - SENTINEL LIGHT		WT - WATER			
METER READ	DUE DATE	GROSS AMOUNT	NET AMOUNT	GROSS DUE AFTER	GROSS AMOUNT	NET AMOUNT	
11/29	12/24	71.68	71.27	12/24/77	71.68	71.27	
NET AMOUNT DUE ON RECEIPT TOTAL AMT. DUE AFTER 12/24/77 IF GROSS AMOUNT NOT RECEIVED BY 12/30/77 FEA PAYMENT DUE DATE YOUR BILL WILL BE 12/30/77 FEA							
						FEA	

Figure 5

Sample TOU Bill--Wisconsin Public Service Corporation

WISCONSIN PUBLIC SERVICE CORPORATION P.O. BOX 1300 GREEN BAY, WISCONSIN 54305 RETURN POSTAGE GUARANTEED					PRESORTED FIRST CLASS MAIL U.S. POSTAGE PAID POST CARD RATE PERMIT NO. 145		
WPS TEL 715-344-5820				<div style="border: 1px solid black; width: 50px; height: 50px; margin: 0 auto; display: flex; align-items: center; justify-content: center; font-size: 2em;">1</div>			
ACCOUNT NO.		PAYMENT DUE BY		NAME ADDRESS			
4/05 5/04		May 25, 78					
NAME							
USED		SERV.		DO NOT MARK OR MUTILATE STUB PLEASE RETURN STUB WITH PAYMENT <div style="text-align: right; font-weight: bold;">103 00</div>			
12386 12948		562 ELEC					
ON-PK KWH		92					
OFF-PK KWH		470					
2845 3033		188 GSHT					
SALES TAX		2.67					
BUD. ADJ. TO		103.00					
41.80CR		103.00					
1.016		.02100					
.00000		103.00					
ANNUAL PERCENTAGE RATES On Installment Contracts 11.25 % On Gas Air Conditioner and Conversion Burner Contracts Before 2/1/74 6.00 %				WISCONSIN PUBLIC SERVICE CORPORATION P.O. BOX 1300 GREEN BAY, WISCONSIN 54305			
NAME		ACT. NO.		FROM DATE TO DATE 04/05/78 05/04/78			
ADDRESS		FROM DATE TO DATE					
<p>THIS MONTH YOU USED 562 KILOWATT HOURS OF ELECTRICITY. 92 OR 16.3 PERCENT WERE USED ON PEAK BETWEEN THE HOURS OF 9 A.M. TO 12 NOON AND 5 P.M. TO 8 P.M. 470 OR 83.7 PERCENT WERE USED OFF PEAK BETWEEN THE HOURS OF 8 P.M. TO 9 A.M. AND 12 NOON TO 5 P.M. AND ON WEEKENDS AND HOLIDAYS.</p> <p>HOW TO SAVE. IF YOU HAD BEEN ABLE TO SHIFT 05 PERCENT OF YOUR TOTAL CONSUMPTION FROM ON PEAK TO OFF PEAK, YOUR ENERGY CHARGE WOULD HAVE BEEN REDUCED BY \$2.60.</p> <p>THIS IS HOW YOU ARE DOING.</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; text-align: center;"> LAST MONTH 687 KWH USED 131 KWH OR 19.00 PCT ON PEAK 556 KWH OR 81.00 PCT OFF PEAK </td> <td style="width: 50%; text-align: center;"> THIS MONTH LAST YEAR 609 KWH USED 111 KWH OR 18.22 PCT ON PEAK 498 KWH OR 81.78 PCT OFF PEAK </td> </tr> </table> <p>ENERGY COST CLAUSE ADJ. .00424 ON PEAK .00053 OFF PEAK</p>						LAST MONTH 687 KWH USED 131 KWH OR 19.00 PCT ON PEAK 556 KWH OR 81.00 PCT OFF PEAK	THIS MONTH LAST YEAR 609 KWH USED 111 KWH OR 18.22 PCT ON PEAK 498 KWH OR 81.78 PCT OFF PEAK
LAST MONTH 687 KWH USED 131 KWH OR 19.00 PCT ON PEAK 556 KWH OR 81.00 PCT OFF PEAK	THIS MONTH LAST YEAR 609 KWH USED 111 KWH OR 18.22 PCT ON PEAK 498 KWH OR 81.78 PCT OFF PEAK						

"COMPARISON" BILLING

The Vermont and Arizona Projects informed experimental customers of the amount payable on the standard (non-TOU) rates with each TOU billing. The Arizona bill itself was a traditional bill, computed on the standard residential rates and altered by hand for the TOU customers. After the traditional bills were prepared by the Customer Records Department in the ordinary manner they were received by the Rate Services Department along with a record of the TOU meter readings; a discount was computed and hand-entered onto the bill after the non-TOU charges were penciled out. A new total and new sales tax were computed and also hand-entered onto the bill. Using pencil to strike out the non-TOU total charge left the bill legible. Moreover, a supplemental worksheet accompanied the bill and presented an explicit computation of the difference between the non-TOU amount due and the TOU total charges. The hand-altered bill was mailed to the customer.¹⁷ Figure 6 is an example of the Arizona bill. The Vermont Project presented experimental customers with both a traditional bill and a non-traditional bill--the bill for the larger amount was marked "void," so the customers always paid the smaller amount.¹⁸ The TOU bills of both the Vermont and Arizona Projects had worksheets which showed the actual computation steps from usage data to total amount due.

The Ohio Project prepared a double bill called a "memo bill" for the first billing period of the study. Traditional rates and experimental rates were both used to compute amounts due, as an informative comparison for the customers. The bills were hand delivered and explained in detail by utility representatives.¹⁹ Carolina Power and Light Company of the North Carolina Project did not compute standard rate charges for their TOU bills but did provide customers with the standard rate equation so they could make

¹⁷Telephone interview, Paul Hart, Arizona Public Service Company, April, 1980.

¹⁸Telephone interview, John Keene, Green Mountain Power Corporation, May, 1980.

¹⁹Ohio Demonstration Project Product User's Guide, no date.

Figure 6

Sample TOU Bill--Arizona Public Service Company

ARIZONA PUBLIC SERVICE COMPANY		aps.		ARIZONA PUBLIC SERVICE COMPANY	
PLEASE ENCLOSE THIS STUB When You Pay by Mail		YOUR METER READ WAS		KW DEMAND or BTU FACTOR	ENERGY USED \$ AMOUNT
PLEASE BRING ENTIRE BILL If You Pay In Person					
P.O. BOX 2907, PHOENIX, AZ 85062		ELECTRIC 45		500	2196
		GAS 2545		1.043	80 15.87
14				TOD DISCOUNT - 2.00	
11 50 1 760312					
2 ST		SERVICE ADDRESS		CURRENT AMOUNT	
6515		2 ST		37.83	
		6515		35.83	
35.83		APPLICABLE SALES TAXES...		1.46	
		(Included in Current Amount)		1.36	
		Your Account Number		C3-12-76 Please Pay	
				Meter Read Date Total Due	
				37.83	
				35.83	
Bill Due On Presentation, and Delinquent After				Disregard Previous Balance If Paid	

the comparison for themselves.²⁰ The Edmond,²¹ Connecticut,²² and Rhode Island²³ Projects computed the non-TOU bills for their experimental customers but this information was not included on the bill the customers received. This was done so that inquiring customers could see the results of the TOU versus the non-TOU rate.

BILLING WITH A NON-TRADITIONAL RATE DESIGN

When the TOU rate structure assigned a different per kwh price to different time periods, an adequate price-signaling bill had only to itemize kwh consumption by time period. More complicated rate designs, however, required a completely different bill design in order to provide an intelligible price signal. The Arizona Project is a case in point. That Project did not bill on a straightforward basis using the sum of products (rate times consumption in rate period); but rather it used a complex discounting scheme based on differences between the level and pattern of consumption during the billing month, and the level and pattern of consumption during the corresponding month of the previous year. Since the TOU meters had been in place collecting baseline data for a full year prior to the start of experimental pricing, there was a previous corresponding month of data. These data were collected when there was no time of use rate; thus, on-peak, mid-peak (shoulder), and off-peak consumptions for a given month during the test could be compared with corresponding consumptions for the same month of the previous year. The discount from the standard rate bill was a function of the comparisons, as well as of the difference in total consumption. The greater the

²⁰Telephone interview, Billy J. Yarborough, Carolina Power and Light Company, April, 1980.

²¹Telephone interview, Neil Dikeman and Marge Early, Oklahoma University (Edmond Project), April, 1980.

²²Telephone interview, Jackalyne Pfannenstil, California Public Utility Commission (formerly with Connecticut Public Utilities Control Authority), April, 1980.

²³Telephone interview, Lewis Bailey, Blackstone Valley Electric Company, April 1980.

shift of consumption from a higher priced tariff period to a lower priced one, the greater the discount; and the greater the decrease in total consumption, the greater the discount. Two other constraints further complicated this billing scheme: 1) no experimental bill was to be greater than what it would have been were the customer not participating in the experiment; 2) if the total energy consumption, as well as the pattern of consumption across tariff periods, were the same in both the test and baseline months, the experimental bill was to be 15 percent less than the non-TOU bill for the corresponding month of the baseline year. (It was possible for the TOU discount to be negative and in such cases the discount must be discarded and the current non-TOU bill submitted as the amount due.) The second constraint required an upward adjustment of the actual kwh's consumed in each tariff period during the corresponding baseline month. The amount of this inflation for each tariff period was calculated to yield a 15 percent reduction. In effect, customers were not directly billed for their consumption in each tariff period, but were awarded savings for their reductions of consumption in each tariff period.

In order to inform customers just how their level and pattern of consumption saved them on their bill, the utility presented them with a detailed report of how the discount was computed. Included with the bill was a copy of the worksheet actually used to compute the bill. The special letter to experimental customers explaining the worksheet and its step-by-step calculations of the TOU discount considerably clarified the billing rationale. However, no account of the procedure or rationale for the upward adjustments to the previous year's energy consumption in the corresponding month was given. The adjusted figures appeared as one line of the worksheet with the following explanation: "Line 4 shows the computed base energy to which this month's energy is compared when determining the time-of-use adjustment that you are entitled to." That "computed base energy" was the inflated value of the previous year's actual kilowatt hour consumption. Utility representatives met with experimental customers at the start

of the Project and explained the rate structure and bill computation. However, it was not clear in the end that the concept of "base kilowatt hours" was thoroughly understood.²⁴

BILL SUPPLEMENTS

Some of the utilities in the Project could not add all of the new components and extra information on TOU billing to their traditional bill forms. The Arizona, Connecticut, North Carolina (Carolina Power and Light), and Wisconsin Projects all found it necessary to add some type of supplement to their bills. As mentioned above, the Arizona bill was accompanied by a copy of the computation worksheet used in its preparation,²⁵ the Connecticut TOU bill had the rate structure printed on its reverse,²⁶ and the Wisconsin Project required an extra page to show the savings.²⁷ Carolina Power and Light presented only the total kwh's consumed and the total amount due on their regular stock form. What amounted to the real TOU bill appeared on a detail sheet, showing the consumption for each of the three tariff periods, the per kwh rate for each, the energy charge and fuel cost adjustment for each, and, if applicable, the peak demand (with date and time of occurrence).²⁸

DATA REQUIREMENTS

In the Projects, billing data included all information requisite to bill preparation: information about consumption as well as collateral information such as the date and time the tape was exchanged, control data (customer identification numbers and record

²⁴This description of the Arizona Project TOU billing scheme is based on the Final Report (February, 1977) of this Project, and on a telephone interview with Paul Hart of Arizona Public Service Company, April, 1980.

²⁵Arizona Demonstration Project, Final Report, Appendix B, February, 1977.

²⁶Final Report: Connecticut Peak Load Pricing Test, May, 1977.

²⁷Telephone interview, Richard E. James, Wisconsin Public Service Corporation, April, 1980.

²⁸North Carolina Demonstration Project Progress Report, February, 1977.

numbers) and even data regarding the condition of metering equipment at the time of tape exchange. Under this general conception of data, any specific information generated by the utility, and not by the customer or the meter, was treated as an input for computing a given bill. For explanatory purposes these billing data were divided into several categories: a) consumption by time, b) control data to insure accurate and valid billing, c) utility generated information necessary to accommodate special features of the rate structure, and d) information required for energy management messages.

Since each of these data categories has at least one aspect which differentiates TOU billing from traditional billing, it is appropriate to consider each of them.

Consumption Data for Time-of-Use Billing

The need for time differentiation of energy consumption in TOU pricing is obvious and little needs to be said here about it. It should be stressed, however, that the multiplication of data incurred a corresponding multiplication of storage and computational capacity. The actual time differentiation of consumption was basically a metering function.

If the rate structure involved a demand component, its load management potential was best realized when the customer's peak demand was specifically located, both by date and by time of day. The utility could have presented customers with records of their peak demand without noting the time, but this would have given the customers little direct assistance in determining the causes of the peak demand. In addition, some rate structures involved a demand component and were concerned with the highest demand that occurred during system peak demand hours, which made time specification indispensable. In general, the inclusion of a demand component in the bill added not one but two items of information: the value of the peak demand itself and the time at which it occurred.

When the rate structure was complex it required as many as seven coordinate items of information to calculate the bill:

consumption in each of three tariff periods; values for the non-coincident peak demand and the coincident peak demand; and the times of occurrence of both of these peaks. This information represented a considerable increase in the data requirements when compared to traditional bills.

Supporting Data to Insure Valid Billing

Any electric bill, TOU or otherwise, must be submitted to the right customer, be based on a correct reading of the meter (including cognizance of the appropriate meter constant), reflect the appropriate rate structure, cover the right billing period, etc. Thus, most of the data that insured these aspects of billing did not differentiate TOU billing from traditional billing. Indeed, when TOU billing was mediated by multi-register watthour meters, about the only supportive information peculiar to TOU billing was the additional information on the condition of the metering equipment. This was required because of the additional complexity of TOU billing and because of the crucial importance of correct time control operation. While this kind of data did not constitute a quantitative input into bill computation, those responsible for the preparation of a valid bill had to be made aware of any significant abnormality in the condition of metering equipment, and particularly aware of evidence that the register shifting time control was leading or lagging the tariff period schedule.

In the case of magnetic tape metering TOU billing required significantly more "control" data than other TOU billing. The time of the tape change at the meter had to be recorded to the minute, rather than simply to the day of the month. This provided an important check against outages and certain forms of meter malfunction. The total kwh reading from the pulse-initiating meter was indispensable for the same reasons. As a matter of course, even when the equipment had carryover capability, independent outage information (time of occurrence, duration, location, etc.) was gathered. Since the equipment itself was considerably more complex than either single or multiple register watthour metering equipment, information about its functional condition was more

important and often more elaborate. Bill computation on the basis of magnetic tape metering required both the meter constant and a "pulse multiplier," a factor to determine the number of watthours presented by each data pulse.

In traditional rate structures the incidence of meter malfunction in single register metering was negligible. The higher incidence of such problems with TOU metering made it advisable to have each customer's past consumption records on hand. When deviations from the customers' historical average occurred during a billing period, these past records were used as a standard of comparison. These records were also an important means of detecting either meter reading errors (translation errors in the case of magnetic tape), computational errors or equipment malfunction. Two Projects—Los Angeles²⁹ and Wisconsin³⁰—used standard criteria for such deviations. Sharp deviations were flagged as doubtful or erroneous and were then subjected to further editing and verification. This became a computer operation when magnetic tape was used as the billing basis.

In the Vermont Project, where paper chart recorders were used, this same comparison was made by visual inspection as part of a bill preparation procedure that was totally manual.³¹

Special Utility-Generated Data

Customer classification interacted with rate structure—a classification for each customer had to be supplied as an additional datum. For example, the Wisconsin Project rate structure had an urban-rural differential superimposed on the TOU differential.³² A seasonal differential was sometimes restricted to a

²⁹Documentation and Review of the Los Angeles Demonstration Project's Data Collection and Editing Procedures Handled by Los Angeles Department of Water and Power, no date.

³⁰Wisconsin Public Service Corporation's Time-of-Use Data Handling System Analysis Capabilities as of May, 1977.

³¹Telephone interview, John Keene, Green Mountain Power Corporation, May, 1980.

³²Wisconsin Demonstration Project Progress Report, January, 1978.

single class of customer. For example, in the Wisconsin Project there was a separate winter rate for electric space heating customers.³³ It could be necessary in some instances to code customers by several cross-classifications, in order to insure application of correct tariffs to their bills.

This apportionment of fuel cost adjustments among tariff periods required considerable amount of utility-generated data. In the North Carolina Project the "rating period constants" which were used to apportion fuel cost adjustments, required the per kwh price for both the season and the tariff period in question. The total kwh sales and the total revenue from energy charges for the billing period were also required.³⁴ A further complication in the use of fuel cost adjustments occurred when such adjustments played a role in the participation incentive. For example, the Puerto Rico Project's fuel cost adjustment was frozen for experimental customers at approximately 2.6¢ per kilowatt hour, but was permitted to rise after one year if the price of fuel had increased by 15 percent.³⁵

As mentioned above, several of the Projects required the production of standard rate bills along with the TOU bills, either for their own purposes or as additional information to customers. When such information was integrated into TOU billing as additional information, an entire second rate structure was, in effect, converted into utility-generated data for TOU billing. While such a procedure may have been applicable only in rate experiments, it was desirable to include it in the early stages of a full-scale TOU pricing project if it highlighted the customers' savings and thus enhanced their load shifting responses to price signals.

³³Ibid.

³⁴North Carolina Demonstration Project Progress Report, August, 1977.

³⁵Puerto Rico Demonstration Project Progress Report, March, 1979.

Data for Energy Management Messages

Records of customers' prior consumption were also useful in providing feedback which encouraged them to shift consumption away from peak periods. The Wisconsin Project bill supplement contained a section entitled "This is how you're doing." It showed the previous month's total kwh's consumed, the number and proportion of kwh's consumed both on-peak and off-peak, and gave similar data for the corresponding month of the previous year.³⁶ As mentioned, the Arizona Project's rate design was based on comparisons between the current month's level and pattern of consumption and like data for the corresponding month of the previous year. Thus load management feedback and encouragement were built into the billing basis itself.

The Edmond³⁷ and Wisconsin³⁸ bills included energy management messages on "potential savings." These messages did not require additional data; only additional computations using data generated for other purposes was necessary. Informing customers that they consumed x percent of their total energy on-peak, and that every y kilowatt hour shifted to off-peak would have saved them z dollars, amount to little more than recasting a part of the bill in a different form. However, the Edmond Project provided one category of customers with peak usage data for their entire metering group, rather than informing them of their own peak usage. This procedure required the use of additional data.³⁹

STORAGE OF CONSUMPTION DATA

Utilities have a variety of reasons to store individual customer's usage records for a considerable length of time. Similarly,

³⁶Wisconsin Demonstration Project Product User's Guide, no date.

³⁷Wisconsin Demonstration Project Product User's Guide, no date.

³⁸Ibid.

³⁹Telephone interview, Neil Dikeman and Marge Early, Oklahoma University (Edmond Project), April, 1980.

complete billing records on each customer are stored, but for a considerably shorter period. The required storage capacity under any TOU rate structure—even with highly summarized data—was greater than that necessary for non-TOU rates. One participant in the Rhode Island Project estimated that the data storage requirement under TOU rates would be three to five times that for traditional rate structures.⁴⁰

With magnetic tape metering, in particular, consumption records were stored on computer tapes, except in the Vermont Project, which retained the circular paper charts from the G-9 demand recorders as both working and permanent usage records.⁴¹ The Puerto Rico Project kept its 15-minute demand data on computer tapes for one and one-half to two months and then converted them to hourly demand tapes for a two-year storage period.⁴² The Los Angeles Department of Water and Power also retained complete consumption data (for both TOU and normal rates) for two years. Ordinarily, these data would be transferred to microfiche for indefinite storage.⁴³ In addition to consumption data, the Los Angeles Department of Water and Power kept a complete billing record for each experimental customer. This record showed each computational step for each bill for two billing periods. The large space requirement for these data was somewhat reduced by storing only day counts, rather than parts of actual tape exchange dates.⁴⁴ The Wisconsin,⁴⁵ North Carolina,⁴⁶

⁴⁰Telephone interview, Lewis Bailey, Blackstone Valley Electric Company, April, 1980.

⁴¹Telephone interview, John Keene, Green Mountain Power Corporation, May, 1980.

⁴²DOE File Document: Notes of Government Technical Representative Paul Johnson, no date.

⁴³Telephone interview, Dennis Whitney, Los Angeles Department of Water and Power, April, 1980.

⁴⁴Ibid.

⁴⁵Telephone interview, Richard E. James, Wisconsin Public Service Corporation, April, 1980.

⁴⁶Telephone interview, Billy J. Yarborough, Carolina Power and Light Company, April, 1980.

and the Los Angeles Projects⁴⁷ used disks as the intermediate storage mechanism while data were being edited, verified and used for actual bill computation. In the Wisconsin Project, each disk was capable of holding all consumption data and associated information for one month, for each of 1,200 customers. After bill computation, the data were stripped from the disk and put end-to-end on customer file tapes. In one year, the Wisconsin Public Service Company generated approximately seven tapes of data from the TOU experiment. These end-to-end tapes were stored indefinitely.⁴⁸

Long-term consumption records were used to handle customer complaints and inquiries. The Arizona Project used hard copy records in handling customer inquiries during the rate experiment. However, Project personnel felt that in full-scale implementation of TOU pricing, the customer answering service would be greatly slowed down by the need to check records and to assimilate diverse records using hard copy. Consequently, Arizona Public Service Company changed to a CRT display with computer stored records to deal with customer inquiries.⁴⁹ Separate records of peak, shoulder, and off-peak consumption for each customer required more storage space in the computer than a single consumption figure.

SUMMARY

The simplest TOU bill format differed from the standard bill only in that both kwh consumption and tariff period charges were itemized. Further additions to TOU bills included demand measures, a TOU differentiation of demand, apportionment of fuel cost adjustments over tariff periods, the price per kwh for each period, and load management information, e.g., a comparison of past and present consumption patterns. Some Projects even included a comparison

⁴⁷Telephone interview, Dennis Whitney, Los Angeles Department of Water and Power, April, 1980.

⁴⁸Telephone interview, Richard E. James, Wisconsin Public Service Corporation, April, 1980.

⁴⁹Telephone interview, Paul Hart, Arizona Public Service Company, April, 1980.

of the total charges under TOU rates with corresponding charges under traditional rates.

Unusual rate designs, as in the Arizona Project, required very complicated bill formats. A supplement showing the steps of bill computation was necessary for adequate understanding by the consumers. Supplements to the bill were required for other reasons, particularly for load management information. Depending upon the complexity of the rate structure, the consumption and demand component of the billing data could comprise as many as seven coordinate items of information: three consumption totals for the tariff periods, plus levels and times of both coincident and non-coincident demand.

Magnetic tape billing particularly required additional data for quality control purposes, i.e., the assurance that billing data had no significant consumption, demand, or time errors. Tape data had to be supplemented with exact tape change times, kwh meter readings at changeout, the meter constant, the pulse multiplier, and outage information. Past records were very important in determining improbable consumption or demand values. These often identified errors or malfunctions.

Many rate structures required special utility-generated data. This included the differentiation of seasonal rates or period changes across customer classes. Sometimes each customer had to be coded for several cross-classifications to assure the application of the appropriate rates. The constants required for correct apportionment of fuel adjustments over tariff periods were derived from utility generated data. Consumption data came from the service area as a whole. Load management information required data from the customer's past records or from the combined consumption history of a group of customers.

The greater data requirements of TOU billing added to the need for expanded storage capacity. Complete records consumed a great deal of space and could not be kept very long without being transferred to a more compact medium than computer tape or disks. On the other hand, research and customer relations required

convenient access to information. Customer relations were ill-served by slow, troublesome searches of the more compact media of storage. Thus a trade-off was established between accessibility and capacity, which required a judgement as to when the data no longer had to be kept in an expanded form.

CHAPTER :
FIVE : THE BILLING PROCESS
:

INTRODUCTION

This chapter examines various aspects of the TOU billing process, a more complex process than billing under traditional rates. This was especially true when magnetic tape metering was used. This type of metering required fairly elaborate computer processing of the "raw" consumption data. The incidence of errors, gaps and other consequences of equipment malfunction was much higher than in other forms of metering. This required an amplification of editing and corrective routines prior to the relatively simple business of computing the bill and delivering it to the customer. Because most of the Projects used magnetic tape metering as the billing basis, and because it was with this metering technique that TOU billing differed most sharply from non-TOU billing, the bulk of this chapter will be devoted to the procedures and problems of preparing magnetic tape consumption (or demand) data used in bill computation. A discussion of these problems, and the ways the various Projects resolved them, should prove helpful to utilities planning to use TOU billing routines.

BILL PRODUCTION EXPERIENCES

Time Requirements

There was considerable variation among the Projects in the total time required for data collection and bill issuance. Blue Ridge Electric Membership Corporation (North Carolina Project) required one week between the pulling of magnetic tape cartridges and issuance of bills.¹ The Connecticut Project required from seven to ten days,² and the Los Angeles Project required between

¹Blue Ridge Electric Membership Corporation Documentations of Usage Data Collecting and Editing and Procedures for All Affected Departments, no date.

²Connecticut Demonstration Project Progress Report, November, 1975.

eight and sixteen days.³ Variation in bill processing time within a single project should also be noted. Simply getting the tape cartridge from the meter to the translator in the Los Angeles Project sometimes took as few as two days or as many as seven.⁴ The Edmond Project displayed a pronounced "learning curve" in its bill preparation time. At the beginning of the study bills were issued about six to eight weeks after meters were read. This time was reduced to a normal interval during the course of the experiment.⁵ One specific contribution to the delays was the Edmond Project's dependence upon an outside contractor for translation and other computer services. The magnetic tape metering vendor translated the tapes for the Project, with a promised turn-around time of five days. At first this delivery schedule was difficult to meet, and data processing was delayed. Bills based on magnetic tapes were issues about two weeks later than those based on two-dial meters.⁶

It was felt by some Project personnel that the greater computational complexity of TOU bills was not directly responsible for prolonging the billing process. The Wisconsin Project found that actual TOU bill rendering computation time was not significantly different from non-TOU billing.⁷ Arizona Project personnel did not feel that computation time would be a significant factor in scaling their experiment up to 350,000 customers. Rather, they thought that non-computational steps in bill production would incur the major cost differential. Such factors as the speed at which bills could be printed and the increased probability of

³Documentation and Review of the Los Angeles Demonstration Project's Data Collection and Editing Procedures handled by Los Angeles Department of Water and Power, no date.

⁴Ibid.

⁵Edmond Demonstration Project Quarterly Progress Report, May 3, 1978.

⁶Telephone interview, Neil Dikeman and Marge Early, Oklahoma University, April, 1980.

⁷Telephone interview, Richard E. James, Wisconsin Public Service Corporation, April, 1980.

two-page bills, along with the necessity of more key punching in order to enter the extra TOU data, added to bill production time.⁸

The Ohio Project wanted to minimize bill delays in order to deliver price signals as soon as possible after usage. Therefore they had to pay for overtime work by some billing personnel, in order to overcome the complexity of the entire procedure from tape exchange to bill issuance.⁹

PREPARING THE DATA FOR BILL COMPUTATION

The "translation" phase of billing occurred only when magnetic tape data were used. Its counterpart in multiregister meter data is key punching or otherwise tabulating the meter readings for bill computation. In the Edmond Project, validating and "editing" multiregister meter data were accomplished before key punching. Incoming meter readings were checked against the customer's past record; unusual readings were returned to the meter readers' supervisor for checking against a second reading. Only after deviant data had been explained and corrected were they re-entered into the bill production stream.¹⁰

Similarly, rate services personnel in the Arizona Project were required to verify or to investigate meter readings which appeared to be out of line with the customer's previous consumption history.¹¹

The Vermont Project used paper chart demand recorders instead of the magnetic tape recording meters used in other Projects. What corresponded to tape translation in the Vermont Project was the direct reading of the demand chart and the tabulation of its data by the collector. The Vermont Project had no formalized program

⁸Telephone interview, Paul Hart, Arizona Public Service Company, April, 1980.

⁹Ohio Demonstration Project Product User's Guide, no date.

¹⁰Telephone interview, Neil Dikeman and Marge Early, Oklahoma University, April, 1980.

¹¹Arizona Demonstration Project, Final Report, Appendix B, February, 1978.

for billing operations. The supervisor of Customer Accounting handled bill computation and all related billing issues, and this task was never delegated elsewhere. The supervisor took the tabular data from the demand charts, the multiregister meter data, and the information on the standard bill for each experimental customer as the data base for the computation of the non-traditional bill. His verification procedure consisted of examining the data for each customer, comparing it to the month-by-month running chart of consumption, and noting whether something "way out of line" appeared in the present bill. If a discrepancy was found, the supervisor consulted metering personnel about possible meter problems, obtained the relevant demand charts, checked the accuracy of data tabulation from the charts, tracked down outages by consulting distribution records, etc. He reviewed the entire data table for each customer before using it for billing. The supervisor was assisted by a clerk who checked his arithmetic but did no interpretive work.¹²

In the Rhode Island Project, meters were read twice, independently, on the same day—once by the regular meter reader and once by the tape collector from the Project. If a tape-to-meter kwh mismatch occurred in translation, the regular meter reader's document was used to see if it was a "better fit." Unusual variance in meter or tape data was detected by comparing newly collected data to the customer's data for the prior month. An experienced billing clerk did the comparing, and brought bill anomalies to the attention of the supervisor. Since there were no routine procedures for validation, the supervisor handled these anomalies on a case-by-case basis. The supervisor's experience and intuitive familiarity with billing were important in resolving these cases.¹³

¹²Telephone interview, John Keene, Green Mountain Power Corporation, May, 1980.

¹³Telephone interview, Lewis Bailey, Blackstone Valley Electric Company, April, 1980.

In the North Carolina Project each customer's bill was compared by hand to the previous month's or year's billing to check for an abnormally high demand or an abnormally high total bill.¹⁴ In the Edmond Project the validation of magnetic tape data was also a "manual" procedure. Previous records of consumption and meter readers' sheets were used as the major collateral input. As in many other Projects, editors inspected printouts of translations, looking for unreasonably high or low consumption. These printouts were then checked against the relevant meter readers' sheets.¹⁵

The Wisconsin Project provides a well documented, representative illustration of the magnetic tape billing process from translation through editing. While the meter tape was being translated, the translator operator entered the customer account number (written on the cartridge) into a minicomputer, which then matched that number to the account number on file for the customer. The operator also entered the set and pull dates of the tape under translation, as well as the meter reading associated with the tape. If the account number did not match the number on file for the customer, or the set date of the present meter tape did not coincide with the pull date of the previous tape, or the initial kwh reading for the present tape did not coincide with the final kwh reading for the previous tape, the data for the tape under translation could not be transferred to a computer tape. The operator then either corrected the defects or scrapped the tape. The computer tape resulting from translation carried the translated meter tape records of many customers. During translation, the time and data pulses were laid down in reverse order from that on the meter tape. The computer tape was then subjected to a re-reversing process during which the translated record was checked. Table 3 lists these checks. If any of the checks listed in Table 3 showed discrepancies, the data for the customer were flagged. The flagged data were then

¹⁴Telephone interview, Billy J. Yarborough, Carolina Power and Light Company, April, 1980.

¹⁵Telephone interview, Neil Dikeman and Marge Early, Oklahoma University, April, 1980.

TABLE 3

Translated Computer Tape Record Checks, Wisconsin Project

Check	Comment
1. The number of simulated time pulses	1. Time pulses were simulated by the translator whenever a "real" time pulse was not found within a certain maximum time since the last "real" time pulse.
2. The number of early time pulses	2. Sometimes a pulse would be simulated by the translator and then the "real" time pulse, supposed missing, would show up. The interval between the simulated and "real" pulses would then be shorter than normal, making the "real" time pulse appear early.
3. The total number of demand intervals	3. The number of demand intervals recorded on the meter tapes should match the total service time of the tape gotten from the meter reader's record.
4. Whether the peak demand was extreme	4. Checked against past consumption patterns.
5. Whether the total kwh recorded on the tape exceeded the usage limit for that customer	5. Usage limits were based on past consumption records.
6. Whether the total number of data pulses on the meter tape yielded a total kwh matching that on the dial meter	6. These two should match or else an error (usually in the tape) is probable.

Source: Wisconsin Project, Wisconsin Public Service Corporations Time-of-Use Data Handling System Analysis Capabilities as of May, 1977.

loaded into the master file kwh record, which kept one month of consumption data per customer. For various reasons, at the time of reversing the present month's record, the master file held the previous month's data. A backlog tape held the current month's data in such cases. Periodically, backlog tape accounts were checked against the remaining accounts with kwh records in the master file and were moved to the master file if, in the interim, the previous month's records had been removed. Transfer of an account to the master file generated a printout, if any of its data were flagged for any of the quality checks in Table 3. A summary printout was also created, listing all accounts moved to the master file and detailing what flags were set. This summary printout and an individual printout for each account containing errors were sent to the billing editors. At this point, all of the magnetic tape data had been translated, reversed into proper time sequence, placed in the master file and printed out. The printouts were sent to the billing editors if they contained error flags. The master file was stored on a disk, allowing random access to the data for editing.

Billing editors worked with CRT terminals. Entering an account number at the terminal called up a display of the account, and at this point the necessary changes could be made in the 15-minute energy data to correct flagged accounts. During editing, the data could be flagged at any 15-minute interval to indicate problems with reliability. The record was flagged for power interruptions and for missing time pulses. The edit routine also flagged simulated time pulses and instances where two or more intervals had been combined. A change made by the editor at the CRT terminal immediately modified the existing master file records on the disk. These records were printed out and showed the changed version of the kwh record. Revisions of the error flags, as well as flags added during the editing stage, were also printed out. At this point, all records were correct, had been corrected by the editing process, or could not be corrected.¹⁶

¹⁶Wisconsin Public Service Corporation's Time-of-Use Data Handling System Analysis Capabilities as of May, 1977.

If a power outage had occurred during the operation of a magnetic tape recorder without carryover¹⁷ the number of time pulses counted from the magnetic tape (TP) multiplied by the time interval (TI) between them would not total the logged service time (TLT) for the tape. That is, $TP \cdot TI \neq TLT$. In case of such a mismatch, the translator flagged the tape. Editors then checked with the distribution department for the outage record that would locate the power interruption and indicate its duration. Wisconsin Public Service Corporation had precise outage records which revealed duration, location, and number of customers affected. An editor with precise data on outages could correct a time mismatch by inserting outage indications of appropriate durations in appropriate places on the tape.¹⁸

Two other Projects had similar techniques for outages. The Los Angeles Project had an automated edit routine for identifying outages which was carried out on its mainframe computer. This program could handle a single outage in the billing period automatically. However, multiple outages required additional information from distribution records.¹⁹

In the Arkansas Project, when outages were indicated in the record, load research personnel at Arkansas Power and Light made the necessary corrections in the data and re-entered them into the editing process. In the Arkansas Project both the time and the duration of power interruptions were part of the information printed when tape data were entered into the master file.²⁰

The Validation-Edit Cycle

The process of rendering data sufficiently valid for billing often took the form of a repeating cycle of inspections and

¹⁷The Wisconsin Project did not equip their meters with carryover.

¹⁸Telephone interview, Richard E. James, Wisconsin Public Service Corporation, April, 1980.

¹⁹Telephone interview, Dennis Whitney, Los Angeles Department of Water and Power, April, 1980.

²⁰Final Report, Arkansas Demand Management Study, no date.

corrections. The data were first reviewed for various errors, before corrective procedures were applied. The resulting modified data set was reviewed again as if it were fresh from the field, and any remaining errors were noted again and the corrective procedures reapplied. This cycle was repeated as necessary.

In the North Carolina Project at Blue Ridge Electric Membership Corporation, the Operations Department translated the meter tapes onto a half-inch computer tape and sent the latter to the Data Processing Department where an initial review to flag all errors was performed. Tapes with errors were returned to the Operations Department along with a kwh computation report, flagging of all errors, and a list of customers who did not have translated cartridges for the billing period. Operations was then responsible for correcting the errors and for estimating missing data. The error correction forms were submitted to Data Processing where they were key punched for computer correction of the half-inch tapes. The half-inch tapes and the key punched error correction form data then produced a new output, which was once again returned to the Operations Department for approval. If the quality of the data was still unacceptable, the cycle from Operations to Data Processing and back again was repeated until data quality was adequate for billing purposes.²¹

In the Puerto Rico Project the translator operator prepared a paper tabulation of each customer. The data included in that tabulation are listed below.

- a. All data from the field card annexed to the cartridge.
- b. Number of demand impulses recorded by the translator.
- c. Number of demand impulses calculated from the total kwh meter reading.
- d. Number of time pulses recorded by the translator.
- e. Number of time pulses calculated from the tape start and pull times recorded by the tape collector.

²¹Blue Ridge Electric Membership Corporation Documentation of Usage Data Collecting and Editing and Procedures for all Affected Departments, no date.

- f. Data to be key punched onto cards (start and stop Julian days, start and stop times, start and stop kwh meter readings, total demand pulses translated, total time pulses translated, and a record number).

The translator sent the computer tapes and their accompanying paper tabulations to the Data Processing Department, where the computer tapes were analyzed by an edit program. With the help of the card data listed in (f) above, this program detected discrepancies in customer identification, dates, and demand and time pulse counts. A list of discrepancies was returned to the Translating Department for correction of miscoded readings or dates. The edit program also flagged missing time intervals, missing demand pulses and other errors. When the error list was returned to the Data Processing Department each customer's data were discarded outright, corrected for missing time or demand pulses, or deemed correct as they were.²²

Validation/verification was initiated in the Ohio Project by careful scrutiny (by an editor) of translation printouts. As in other Projects, this operation was repeated after each effort at correction until data were of adequate quality for billing and entry into the history file.²³

Frequency of Editing

Magnetic tape data generally required more editing than multi-register meter data. This was mainly due to the greater number of malfunctions when using magnetic tape meters. About 7 percent of the meter tapes in the Ohio Project required some editing.²⁴ For example, the need for editing was mainly caused by time errors due to power outages, faulty tape or clock drives, faulty impulse generators, time zone changes, missing data due to tape runout or breakage, or defects in the recording heads.

²²Puerto Rico Demonstration Project Procedures of Collection, Translating and Editing of Field Data, no date.

²³Ohio Demonstration Project Product User's Guide, no date.

²⁴Ibid.

Carolina Power and Light found about fifteen to twenty percent of the meter tapes needed special handling.²⁵ The Los Angeles Project reported that nine to twenty percent of their TOU bills required special attention because they were estimated or incorrect.²⁶

The Wisconsin Project found that about thirty percent of the meter tapes needed some editing. Twenty percent were successfully edited prior to bill computation but the remainder were unusable for billing purposes. Half of this ten percent were corrected at a later stage for analytic (non-billing) purposes, leaving five percent totally uncorrectable and flagged as unreliable.²⁷

Criteria of Billing-Adequacy in Data

There were usually tolerances in validating the data. Discrepancies between the meter reader's time and the tape time did not have to be zero for bill computation to proceed. Nor was it necessary for the discrepancy between the meter reader's kwh total and the tape kwh total to be zero. In the North Carolina Project, if the time interval difference between the tape and the reader's log was three or less, and no explanation (e.g. power outage) for the discrepancy could be found, the data were treated as if there was no difference at all, and billing would proceed without modification of the data. The mismatch tolerance between tape and reader's log in kwh's was a function of the total consumption for the billing period. If total consumption was 500 kwh's or less, and the discrepancy was within five percent of the meter total, the data pulse record of consumption was used as the measure of total kwh's. If total consumption was more than 500 kwh's, this

²⁵Telephone interview, Billy J. Yarborough, Carolina Power and Light Co., April, 1980.

²⁶DOE File Document: Memorandum, Armstrong to Whitney, Responses to DOE Questions on Processing and Editing of Consumption Data of the Los Angeles Electricity Rate Study, July 22, 1978.

²⁷DOE File Document: Notes from 6/29/77 Meeting with Dick James.

TABLE 4

Error Criteria for Billing Adequacy
Wisconsin, Los Angeles and Puerto Rico

Project	Error Criteria
Wisconsin	<ul style="list-style-type: none"> a. Meter tapes and meter readers' times must match to within 15 minutes. b. The peak was extreme if the maximum 15 or 60 minute demand was 1.8 times greater than the next highest 15 or 60 minute demand, respectively. c. Kwh's from tape and meter must be within 6 kwh's and 1 percent of one another.
Los Angeles	<ul style="list-style-type: none"> a. Kwh total from tape had to be within 3 percent of the total from the meter dial. b. The time computed from tape time pulses and time logged by the tape collector had to be within one interval.
Puerto Rico	<ul style="list-style-type: none"> a. Customer number must match file number. b. Start time plus recording time had to equal a previously given time of duration. c. An adequate approximation of kwh's from the tape to that from the meter had to exist. d. Time by pulse count had to coincide with time gotten from start/pull record.

Source: Compiled from Wisconsin Public Service Corporation. Time-of-Use Data Handling System Analysis Capabilities as of May, 1977, Documentation and Review of the Los Angeles Demonstration Project's Data Collection and Editing Procedures Handled by Los Angeles Department of Water and Power, (no date), and Puerto Rico Demonstration Project Progress Report, April-June, 1977.

tolerance had to be one percent or less. When the registration on the watt-hour meter was deemed to be accurate but the tape data were not within the tolerance, the assignment of consumption to time periods was normally left unchanged as it came from the translation process. This was because it was assumed that the type or recorder malfunction that led to this problem ordinarily caused data to be lost from all time periods equally.²⁸

The error criteria for billing adequacy for Wisconsin, Los Angeles, and Puerto Rico are shown in Table 4. If the data did not meet these basic criteria they were not admitted to the billing file. Some of the data was edited and then if it met the criteria it was used for billing.

ESTIMATION OF MISSING DATA

In the course of validation and editing a record was sometimes flagged as completely unreliable and uncorrectable, because data were missing from most of the meter tape. In such cases the current bill had to be based upon an estimation. Also, when data had to be inserted into a relatively small gap in the record, the missing data had to be estimated. In the Connecticut Project the inserted data were based upon the customer's pattern of usage for at least eight days prior to the missing data, and on the total kwh consumption for the entire month. These latter data came from the watt-hour meter reading taken at the time of the tape exchange.²⁹

The Los Angeles,³⁰ Wisconsin³¹ and Puerto Rico³² Projects

²⁸Carolina Power and Light Co. FEA Peak Load Pricing Administrative Procedures, March, 1978.

²⁹Connecticut Peak Load Pricing Field Test Product User's Guide, no date.

³⁰Documentation and Review of the Los Angeles Demonstration Project's Data Collection and Editing Procedures Handled by Los Angeles Department of Water and Power, no date.

³¹Wisconsin Public Service Corp. Time-of-Use Data Handling System Analysis Capabilities as of May, 1977.

³²Puerto Rico Demonstration Project Procedures of Collection, Translating and Editing of Field Data, no date.

allowed the extrapolation of fourteen days of good data in order to make a tariff period allocation of total kwh consumption throughout the rest of the billing period. Estimations based on fewer than fourteen days were not considered sufficiently stable. In the Connecticut Project, extrapolations on the basis of eight days' good data were used, but they used this procedure only when two days or less of missing data were to be filled in.³³

When less than fourteen days of consumption data were available on a defective tape, both the Los Angeles³⁴ and Puerto Rico Projects³⁵ estimated bills. There were two different remedies or ways to estimate the bill when meter data were defective or incomplete. One of these was used when data existed for the prior billing period. In this case bills were extrapolated to the current billing period by use of a set pro-rating formula.³⁶

A second remedy was used when there was an absence of good data in the prior billing period. In this case the tape that replaced the invalid tape was left in the meter at least fourteen days, but it was pulled before the normal billing cycle was completed. This "short" tape was then used as the basis for estimating total kwh's and the peak and off-peak consumptions during the "bad data" cycle. Again a set pro-rating formula was used for calculating the estimated bill.³⁷

The Wisconsin Project proceeded somewhat differently in such cases. They used one of three estimation methods: 1) a statistical (least squares) projection from the most recent fourteen month's billing parameters to the current month's parameters;

³³Connecticut Peak Load Pricing Field Test Product User's Guide, no date.

³⁴Documentation and Review of the Los Angeles Demonstration Project's Data Collection and Editing Procedures Handled by Los Angeles Department of Water and Power, no date.

³⁵Puerto Rico Demonstration Project Procedures of Collection, Translating and Editing of Field Data, no date.

³⁶See memorandum from Dennis Whitney, Los Angeles Department of Water and Power, April 30, 1977, "Revised Formulas for Handling Unusual Billing Cases," for the formulas for estimating the bills.

³⁷Ibid.

2) an extrapolation of the corresponding month's parameters from the previous year; and 3) extrapolation of the preceding month's parameters. Selection among these was determined by the accuracy with which each characterized the most current month with perfect data. In the rare cases when data were lost, Wisconsin Public Service Corporation billed experimental customers as if they were not on TOU rates. They sought to avoid this if possible because of equity considerations. If the customer had been trying to save under TOU rates it would have been unfair to give him a non-TOU bill.³⁸

In two Projects, Edmond³⁹ and Arkansas,⁴⁰ a customer's on- and off-peak distribution of kwh's was estimated by using the ratio of on-peak consumption to total consumption for the experimental group to which the customer belonged. This method was sometimes used in the Edmond Project, but it was not preferred. When possible, missing data were estimated with the customer's own past consumption pattern.⁴¹ This was the case in most of the other Projects.

In the Connecticut Project, when a bill had to be estimated because no usable magnetic tape data existed, the estimation was performed by a member of the Connecticut Public Utilities Control Authority staff. This person examined the customer's previous year usage pattern and the previous month usage pattern under the TOU rate. In every case the total kwh consumption was available from the meter reading. The frequency of total bill estimations was actually very low in the Connecticut Project. Perhaps no more than five such estimates were performed during the test

³⁸Telephone interview, Richard E. James, Wisconsin Public Service Corp., April, 1980.

³⁹Telephone interview, Neil Dikeman and Marge Early, University of Oklahoma, Apr-1, 1980.

⁴⁰Telephone interview, David Bryant, Arkansas Power and Light Co., April, 1980.

⁴¹Telephone interview, Neil Dikeman and Marge Early, University of Oklahoma, April, 1980.

year.⁴²

POST-EDITING DATA CHECKS

Most Projects performed some kind of final quality checking after editing. Most of this consisted of bill verification procedures carried out after computation. These checks are listed in Table 5 for the Edmond, Los Angeles and Arkansas Projects.

In the Edmond Project, bills were prepared by the University of Oklahoma. An analyst at the university then checked all magnetic tape-based bills against the previous month's consumption data.⁴³ The City of Edmond made a final check before bills were mailed to customers. The size of the Los Angeles Project made a permanent billing error control operation worthwhile. One full-time worker was assigned to monitor billing, customer moves, disenrolls, meter failures and other events. Part of the validation/verification process in some Projects consisted of auditing routines that checked bills on a sample basis. For example, a contractor for the Los Angeles Department of Water and Power wrote a semi-automatic auditing program for TOU billing.⁴⁴

Some Projects monitored data prior to or parallel with the remainder of bill production after editing. In the Arkansas Project there was a monthly monitoring operation to determine the accuracy, reliability and consistency of the data. This monthly monitoring of experimental data provided the basis for post hoc detection of billing errors.⁴⁵

In the early phases of the Wisconsin Project, bills were verified by hand. The accumulation of consumption into tariff

⁴²Telephone interview, Jackalyne Pfannenstiel, California Public Utilities Commission (formerly with Connecticut Public Utilities Control Authority), April, 1980.

⁴³Telephone interview, Neil Dikeman and Marge Early, University of Oklahoma, April, 1980.

⁴⁴Minutes of Quarterly Review Meeting, Los Angeles Demonstration Project, April 13, 1977.

⁴⁵Final Report, Arkansas Demand Management Demonstration Study, no date.

TABLE 5

Post-Editing Data Checks For Bill Accuracy
Edmond, Los Angeles and Arkansas

Project	Check
Edmond	<ol style="list-style-type: none"> 1. Review kwh consumption history, contrast it to present month to identify variations in meter reading. 2. Comparison of bill on experimental rate with a bill computed on standard rates. 3. Maintenance of a file for each household to help identify events affecting data quality.
Los Angeles	<ol style="list-style-type: none"> 1. Did sum of peak kwh and off-peak billed for equal final meter reading minus beginning meter reading? 2. Recomputation of peak portion of bill. 3. Recomputation of city and state taxes. 4. Perform inverse computation to recover the rate used. 5. Check addition of the total 6. Check that bill was not for a "short" period--less than full billing period.
Arkansas	<p>A monitoring procedure to produce the follow-seven summary statistics for each experimental customer.</p> <ol style="list-style-type: none"> 1. Demand at time of system monthly peak. 2. Peak demand during peak period. 3. Demand at time of control group peak 4. Kwh usage during peak. 5. Individual load factor for the month. 6. Peak demand at the hour ending 11:00 A.M. and 8:00 P.M. 7. Load factor within in the peak period (a test for needle peaks).

(continued)

TABLE 5 (continued)

Source: Compiled from data in Edmond Demonstration Project Report, November 30, 1977; DOE File Document: Memorandum, Armstrong to Whitney, July 22, 1978, Responses to DOE question on processing and editing consumption data of the Los Angeles Electricity Rate Study, and Final Report, Arkansas Demand Management Demonstration Study, (no date).

periods, seasonal rate changes, and maximum demand were all subject to manual check. Some amount of hand verification continued throughout the Project. In the latter phases, approximately one percent of the bills were audited by hand.⁴⁶

In Wisconsin even records that passed the reversing process checks and were corrected by editing were not used for billing until they passed a series of checks called "billing qualification." In this process the tape and meter kwh totals and the tape and meter reader's times were compared once more. The service period was also checked to determine that it was not less than 25 days or more than 35 days, and the time and consumption data were re-checked for error flags. Two special flags were watched for when the rate structure had a demand component. The peak demand interval was not allowed to be bounded by a simulated time pulse; and it could not be longer than 16 minutes. Furthermore, the demand in that interval could not exceed a predetermined limit. For the most part, the billing qualifications check was a repeat of the validation/verification checks carried out at translation and reversing.⁴⁷

BILL COMPUTATION

The next step in the billing process was the computation of the bill. This step usually involved processing the edited data and placing it, either manually or by computer, on the bill. For example, the Edmond Project's corrected magnetic tape data were key punched onto computer cards, rather than left on tape, so that they could be merged with the two-dial meter data for bill computation.⁴⁸ Past due data were also merged with the metering data for bill computation. Prepared bills and data printouts

⁴⁶Telephone interview, Richard E. James, Wisconsin Public Service Corp., April, 1980.

⁴⁷Wisconsin Public Service Corporation's Time-of-Use Data Handling System Analysis Capabilities as of May, 1977.

⁴⁸Edmond Demonstration Project Quarterly Progress Report, August, 1977.

were then returned to Central State University (CSU) in Edmond. That subcontractor integrated customer information with the bills and performed accounting tasks. They then sent the printouts, bills, customer information and addressed envelopes to City Utilities of Edmond. The City then mailed the bills to the customers. Accounting information (the list of accounts, amounts billed as of billing date, and the accounts to be credited on receipt of payment) were sent to the CSU Computer Center. The computer center delivered an up-dated list of past-due accounts to City Utilities of Edmond and also sent a copy of that list to the CSU Economics Department.⁴⁹

The Los Angeles office responsible for the Project calculated the experimental bills from translated tapes and then turned over "pre-computed bills" to the Los Angeles Department of Water and Power's Commercial Department for further bill preparation and mailing.⁵⁰

The TOU billing process in the Vermont Project was entirely manual. The standard bill was computed on the utility's main-frame computer. Bills for experimental customers were pulled out of the regular process before mailing. They were given to the Supervisor of Customer Accounting who computed the non-traditional component. Whichever of the two bills had the greater total amount due was stamped "Void," and the customer paid the lesser bill.⁵¹

In the Vermont Project, the "off-peak" non-traditional rate incorporated both an on and off-peak price differential and, within each pricing period, a tariff that varied with the quantity of energy consumed.⁵²

⁴⁹Edmond Demonstration Project Quarterly Progress Report, May, 1977.

⁵⁰Telephone interview, Dennis Whitney, Los Angeles Department of Water and Power, April, 1980.

⁵¹Telephone interview, John Keene, Green Mountain Power Corporation, May, 1980.

⁵²Telephone interview, Lewis Bailey, Blackstone Valley Electric Co., April, 1980.

After the tapes were translated, the billing procedures in the Rhode Island Project were manual. The translator yielded a "billing analysis" comprising the kwh consumption for on- and off-peak tariff periods. It also printed out the customer's peak demand during system peak hours, the peak demand during the system off-peak hours and the peak demand for the entire month. Bills were hand calculated from a hard copy of this billing analysis. The hand computed TOU bill and a regular (non-TOU) bill were prepared by a computer and logged together in permanent records. The regular bill was used for purposes of comparison.⁵³

A MISCELLANY OF ERRORS

All of the Projects encountered errors in the billing process. Some of these were due to billing routines, but others were carry-overs from meter reading. For example, both the Edmond⁵⁴ and Puerto Rico⁵⁵ Projects found that the majority of their correctable billing errors were due to mistakes in meter reading or tape change-out, although once in the Edmond Project, thirty households were mis-billed when their consumption data were not entered in the computer.⁵⁶

Rhode Island meter readers would occasionally err in logging the date of their readings. The proper date was determined by referring to each customer's billing cycle.⁵⁷

Thirty-three Connecticut Project customers were incorrectly billed because of errors in the start-time indication on meter

⁵³Ibid.

⁵⁴Telephone interview, Neil Dikeman and Marge Early, University of Oklahoma, April, 1980.

⁵⁵Puerto Rico Demonstration Project Procedures of Collection, Translating and Editing of Field Data, no date.

⁵⁶Edmond Demonstration Project Progress Report, November, 1977.

⁵⁷Telephone interview, Lewis Bailey, Blackstone Valley Electric Company, April, 1980.

tapes. These errors ranged from \$1.84 to \$9.50.⁵⁸

Carolina Power and Light's bill computation program was tested during a month where there was no seasonal rate change. Consequently, the programmers overlooked the need for this step. When billing went from winter to summer rates, the computer continued to use winter rates instead of switching to summer rates. This problem was not discovered for fifteen billing cycles when customer complaints called it the utility's attention.⁵⁹ Another billing error--or potential for error--stemmed from defects in software. This occurred in the Los Angeles Project, where a sub-program of the TOU billing program which allocated consumption to peak and off-peak periods when there was tape failure was apparently not correct during its first operation.⁶⁰

There were three principal causes of mismatch between the start and pull times and the service time computed from the number of 15-minute intervals. One of these was power outages. Power outages caused fewer time pulses on the tape than those on computer from the start and pull times. This was usually corrected during editing by inserting enough intervals, with zero consumption, to correct the time difference. If two or more intervals were added together at translation a condition called "stacking" a shortfall of recorded time pulses (relative to the logged start and pull times) resulted. This condition was corrected by splitting stacked intervals into correct lengths and distributing the data pulses among them. Carolina Power and Light Company used this technique to correct for stacking only when the number of stacked intervals was no greater than sixteen. Otherwise, no correction was made and an estimation procedure was substituted.⁶¹ The third

⁵⁸Connecticut Demonstration Project Progress Report, November, 1975.

⁵⁹Telephone interview, Billy J. Yarborough, Carolina Power and Light Co., April, 1980.

⁶⁰Los Angeles Demonstration Project Progress Report, June, 1976.

⁶¹Carolina Power and Light Company FEA Peak-Load Pricing Administrative Procedure, March, 1978.

main cause of time discrepancies was "splitting"--the inverse of stacking. In this case, the number of time intervals exceeded the number computed. This was caused by the insertion of simulated time pulses where none should have been inserted. The correction for "splitting" was "stacking," combining multiple intervals into a single interval. As for stacking, this correction was applied by Carolina Power and Light only if no more than sixteen extra intervals had been created by splitting.⁶²

One effect of the "stacked interval" was a doubling or tripling of the apparent demand in an apparent 15-minute interval. This occurred in a few cases during the North Carolina Project and was particularly critical in those cases where the bill had a demand component. Some customers with a demand component in their rate structure were erroneously billed for almost twice their actual peak demand. This was apparently because two or more 15-minute intervals of data were "stacked" as a single 15-minute interval.⁶³ This problem points up the importance of comparing the current consumption record to previous months' or years' billing records.

PROBLEMS ARISING IN SPECIAL FEATURES OF THE PROJECTS

Examination of problems unique to the Projects in which they occurred can be instructive, as an outline of the possible difficulties.

A billing problem in the Edmond Project arose because most accounts were transferred to the experimental billing cycle in the middle of their old billing cycle. The last bill from the old cycle was dated at the end of the normal cycle instead of when the meter was actually read. The result was that although the bill appeared to be for a full billing period it reported a low level of consumption. The experimental bill was actually

⁶²Carolina Power and Light Company FEA Peak-Load Pricing Administrative Procedure, March, 1978.

⁶³Telephone interview, Billy J. Yarborough, Carolina Power and Light Co., April, 1980.

for one month but, arriving as it did in the middle of the old cycle, seemed to cover only eight to ten days. Customers thought there had been a dramatic rate increase.⁶⁴

A billing problem peculiar to the Wisconsin Project came about from the interaction of the seasonal rate structure and the fact that customers were on different billing cycles. When the change from summer to winter rates was effected between billing cycles, some customers were on different seasonal rates than others. This complicated the billing analysis considerably. In order to simplify the analysis, it was necessary to bill each affected customer at the appropriate rate (winter or summer) for the fraction of his billing period to which that rate applied. In this case simplicity of bill computation was sacrificed to simplicity of experimental analysis.⁶⁵

A significant addition to the Los Angeles Project's data processing load was caused because meter data from both TOU customers and load study customers were mixed prior to bill computation. These records had to be split into separate daily record tapes for TOU seasonal and load study customers. This sometimes involved as many as five different daily records tapes, temporary disk storage, and approximately two hours of computer time.⁶⁶

The Los Angeles Project had a special purpose minicomputer which was used for "account tracking." This computer received the "pre-computed bills" that were kept in ledgers to distinguish paid-up customers from delinquent ones. Through an oversight, this computer's programming omitted automatic notification of delinquent customers. The Project assumed that this function was operative. Consequently, the delinquency rate increased significantly and some customers did not pay bills for as much as six months. The minicomputer program could not order delinquent accounts according

⁶⁴Edmond Demonstration Project Progress Report, August, 1977.

⁶⁵Telephone interview, Richard E. James, Wisconsin Public Service Corp., April, 1980.

⁶⁶Telephone interview, Dennis Whitney, Los Angeles Department of Water and Power, April, 1980.

to the length of time they were overdue. Therefore, it was necessary to print out a list of all delinquencies once each month, hand-check this list and send notices to all accounts more than twenty-nine days delinquent. Accounts over forty-five days delinquent received termination notices.⁶⁷

EDUCATION, EXPERIENCE AND SPECIAL TRAINING

Some of the Projects relied heavily upon the work experience of senior personnel in most phases of the work experience of senior personnel in most phases of the billing operation. In the Vermont Project, for example, the supervisor of Customer Accounting, a senior worker with many years of general billing experience, was solely responsible for TOU billing. He even computed each experimental bill himself and relied on clerical assistance only for checks on his arithmetic.⁶⁸ An experienced senior billing clerk in the Rhode Island Project was responsible for bill computation and for the first stages of validation and editing. This person was responsible for detecting anomalies in each customer's billing data and bringing them to the attention of the supervisor. The supervisor made the requisite editing decisions and performed all estimates of missing data.⁶⁹ Heavy reliance on the billing experience of senior personnel typified most informal, highly "manual" operations. However, the more formalized automated billing operation at Carolina Power and Light (North Carolina Project) also depended upon the general work experience of many Project personnel. The Project leader, senior systems analyst, and the billing software programming team all had from six to twelve years of experience with load survey and large customer accounting using magnetic tape meters. At the beginning of the Project they were already competent to write a broad

⁶⁷Ibid.

⁶⁸Telephone interview, John Keene, Green Mountain Power Corp., May, 1980.

⁶⁹Telephone interview, Lewis Bailey, Blackstone Valley Electric Co., April, 1980.

variety of relevant software. Less experienced personnel were assigned to work with more experienced personnel. The clerks handling the bills were, for the most part, high school graduates whose work experience varied. Their supervisors were college graduates who, prior to the Project, had been managers or accountants in field offices.⁷⁰ The billing editors in the Wisconsin Project were regular billing personnel at the top end of Wisconsin Public Service Corporation's non-supervisory qualification scale. For the most part they were high school graduates.⁷¹ In the Los Angeles Project the personnel responsible for tape translation were high school graduates with four years of work experience. Most of their experience involved magnetic tape metering equipment.⁷²

Technical expertise, particularly in the area of software development, was indispensable to the majority of Projects. One member of the Wisconsin Project staff observed that even if the utility had acquired a complete TOU billing software package, the problems of incorporating it into the utility's system would have required programmers who were capable of reconstructing the software package from scratch.⁷³ The Los Angeles Project employed one full-time programmer, a senior programmer/administrator, a programmer/analyst, a statistician and a senior economist/statistician, as well as a full-time research assistant, in its billing related activities.⁷⁴ The less elaborate Edmond Project employed a full-time billing analyst and a programmer. The

⁷⁰Telephone interview, Billy J. Yarborough, Carolina Power and Light Co., April, 1980.

⁷¹Telephone interview, Richard E. James, Wisconsin Public Service Corp., April, 1980.

⁷²Telephone interview, Dennis Whitney, Los Angeles Department of Water and Power, April, 1980.

⁷³Telephone interview, Richard E. James, Wisconsin Public Service Corp., April, 1980.

⁷⁴DOE File Document Memorandum: Armstrong to Whitney, January 27, 1978: Delivery of the First Experimental Data from the Study to the Department of Energy Due on February 28, 1978.

programmer worked full time in the early phases of the Project but was eventually reduced to one-quarter time.⁷⁵

Engineers were the principal supervisory and administrative personnel in the Wisconsin Project. The programmers who developed the Wisconsin data handling system reported to the engineers and submitted all proposed programs and systems changes for their review.⁷⁶

Some Projects supplemented the educational and work-experience qualifications of personnel with specific training in various aspects of TOU billing. Specific training of the senior clerk in the Rhode Island Project has already been mentioned. The North Carolina Project provided additional training for its billing personnel.⁷⁷ The Wisconsin⁷⁸ and Arizona Projects held training sessions for customer contact personnel. The Arizona held half-day sessions covering billing errors and other problems which customers were likely to inquire about. Two such sessions were normally required to bring these personnel to adequate competence.⁷⁹ The Arkansas Project held training sessions for billing clerks to alert them to the special features of TOU billing and to initiate them to procedural changes. These training sessions were backed up by internal instructional memoranda.⁸⁰

⁷⁵Telephone interview, Neil Dikeman and Marge Early, University of Oklahoma, April, 1980.

⁷⁶Telephone interview, Richard E. James, Wisconsin Public Service Corp., April, 1980.

⁷⁷Telephone interview, Billy J. Yarborough, Carolina Power and Light Co., April, 1980.

⁷⁸Telephone interview, Richard E. James, Wisconsin Public Service Corp., April, 1980.

⁷⁹Telephone interview, Paul Hart, Arizona Public Service Co., April, 1980.

⁸⁰Telephone interview, David Bryant, Arkansas Power and Light Co., April, 1980.

MISCELLANEOUS INFORMATION ON THE COSTS OF TOU BILLING

Billing in the Projects was generally expensive. Rhode Island Project estimated that the TOU billing costs ran approximately twice those of ordinary billing.⁸¹ In the Ohio Project TOU billing cost approximately \$13 per customer per month.⁸² Connecticut Project billing ran about \$4,000 per month (or approximately \$10 per customer per month). This was an over-expenditure of \$25,000 beyond the total billing expenditure budgeted in the original proposal for the Project.⁸³

Simply establishing the error control program in the Los Angeles Project required one full-time research assistant, four person-weeks of staff work and \$8,000 of computer time. The total cost was in the neighborhood of \$40,000.⁸⁴ The Los Angeles Project's editing was estimated to cost \$2,000 per month.⁸⁵

SUMMARY

The amount of time needed for bill processing varied from Project to Project. In the earlier phases of the tests it ranged from one to eight weeks. Experience with TOU billing tended to reduce the time required. Greater computational complexity probably lengthened the process less than did the many supporting steps, such as keypunching, editing of data, printing multipage bills, stuffing envelopes, and so on.

⁸¹Telephone interview, Lewis Bailey, Blackstone Valley Electric Co., April, 1980.

⁸²Ohio Demonstration Project Product User's Guide, no date.

⁸³Quarterly Review of Connecticut Peak Load Pricing Field Test, no date.

⁸⁴Minutes of Quarterly Review Meeting, Los Angeles Demonstration Project, April 13, 1977.

⁸⁵DOE File Document Memorandum: Armstrong to Whitney, July 22, 1978: Responses to DOE Question on Processing and Editing of Consumption Data of the Los Angeles Electricity Rate Study.

Magnetic tape billing began with the translation of pulse data into a computer readable code. These data then had to be verified or validated. This included checks of a number of possible errors in the measurement of demand or consumption against time. The routine data quality checks included comparisons of kwh totals from meter dials with tape kwh totals and a comparison of tape determined service time with logged changeout times. Other checks were the inspection of data for improbable deviations from past demand or consumption levels and detection of short time intervals and missing time pulses. Billing editors corrected these errors and resubmitted the altered data for a subsequent quality check. Validation and editing cycle were alternated until the data met billing criteria or were discarded in favor of an estimate.

The incidence of editing magnetic tape data was fairly high in most Projects. Some of this was due to the vulnerability of this technology to malfunction and error. Common problems included time errors due to outages, missing data due to tape-run out and tape exchange errors, and mechanical and electrical breakdowns that caused time errors or destroyed data. Between nine and thirty percent of the tapes needed some sort of special treatment.

Tape data in less than perfect condition were accepted for billing although the criteria of adequacy were stringent. If data could not be brought to within the tolerances, bills were estimated. Typically the estimation basis was at least 14 days of good data for filling out the rest of the billing period. There were various schemes of extrapolating past consumption patterns to estimate an entire billing period.

Post-editing checks of bill quality were usually employed. These were sometimes done by auditing a sample of the bills. These controls involved many validation and quality checks as well as recomputations of all quantities on the bill.

For the most part, actual bill computation under TOU rates was not much more difficult than computation of traditional bills. The errors and breakdowns reported by the Projects were

generally the sort to be expected in unfamiliar operations with complex equipment. In nearly every case once they were detected the problems were speedily corrected and policies were formulated either to prevent their recurrence or to deal with them automatically. As the personnel in the Projects learned to deal with the new system, TOU billing became a more efficient process.

Personnel requirements for TOU billing ranged from one individual who did nearly everything to six specialists working in cooperation with a large billing department. Some training for TOU billing was involved in most of the projects, but the general work experience of personnel was significant. The less formalized, more "manual" billing operations relied most upon the experience of senior personnel, but the technical people in the most automated Projects also tended to have experience in some related operations.

CHAPTER :
SIX : SUMMARY
:

TOU billing was unavoidably more complicated than traditional rate billing. It required the incorporation of more data into the bill design, more extensive processing of the data, and more effort for prevention and correction of errors.

When billing was based on magnetic tape metering, TOU billing involved extra equipment such as tape translators and verifiers, special-purpose computers, and a more complex variety of software. These requirements in turn introduced additional opportunities for error and mechanical failure. Particularly, due to the need for new equipment, the operation of which was not always adequately understood by utility personnel, there was an increased dependence on outside vendors for quality equipment and for assistance in its proper operation. These outside dependencies were potential causes of delay and false start.

The overall complexity and novelty of TOU billing was expected to cause more customer inquiries and complaints. This turned out to be generally true and customer relations personnel had to be adequately prepared to handle these situations.

Acquiring all of the equipment for magnetic tape billing was not always a routine affair. It was necessary to prepare very detailed specifications for the performance capabilities of this equipment. Almost all of the commercial software packages used for data processing had to be adjusted to match the utility's established billing and analysis routines. One conclusion from this is that no set of bid specifications, however detailed, is likely to eliminate post-purchase programming. Even though the equipment was carefully selected and adjustments were made to adapt the hardware and software to the utility's requirements, there were usually oversights in programming, delays in delivery, breakdowns, maintenance failures, etc. These necessitated a "shakedown" period, during which operations were substandard. The length of this period often depended upon the quality of the

working relationship between the utility and its outside vendors. It appears that some of these problems can be lessened by involving utility computer personnel in all aspects of acquiring the billing equipment and software packages.

Utilities developing their own computer programs for billing should expect a rather heavy investment in programming personnel for a considerable period. The programming for tape translation and data quality control is of the "real time" variety. This is much more complex--and unfamiliar to most programmers--than applications in which data intake can be scheduled according to program requirements.

Serious data loss resulted from what seemed to be small errors of changeout procedure. Consequently, field personnel responsible for collecting and installing magnetic tapes in the meters had to be thoroughly trained and tested. As indicated by the Edmond Project experience, the vendor of the magnetic tape equipment could not always be relied upon to provide adequate training. In general, the utility had to take active and nearly complete responsibility for each phase of establishing the TOU billing system. This seems to be true regardless of the degree of commercial pre-development of the equipment, software, and operational instruction. One important way of foreseeing and forestalling many problems, was extensive and detailed consultation with key personnel of other utilities which had used magnetic tape TOU billing.

There were significant complications in designing TOU bills. Full price-signal exploitation of the rate structure led to bill formats which presented:

- total kwh consumption
- kwh consumption by rate period
- apportionment of fuel cost adjustments over rate periods
- date, time, and level of customer's peak demand
- various types of load management information, including comparisons of present to past consumption patterns, demand shifting advice, etc.

A full billing format sometimes required a utility to shift from card billing to letter billing, or to print multi-page bills, or to add various supplements to the bill. Production time and costs almost always increased when this format was used.

When more complex bill designs were used, data requirements were greater and required expanded storage capability for customer records. A more elaborate means of gaining access to data was needed in order to promptly handle customers' billing complaints. Magnetic tape metering in particular increased the need for control information to assure valid billing.

At first, most projects found TOU billing to be a long process, but with experience, bill production time usually fell to near normal. Given the complexity of the whole process from tape changeout to mailing the bill, there was much to learn. Since data collection, in magnetic tape billing, was not done at the meter but in a machine for converting magnetic impulses into numbers, important and difficult steps were added to the billing process. Data had to be translated and validated, i.e. determined to be accurate enough for billing purposes. The experiences of the Projects indicate that these data, at this stage, are not likely to be sufficiently accurate for billing. The incidence of editing, i.e., adjusting defective data to meet billing requirements, was very substantial in most Projects. This was especially true early in the Projects. Thus, after translation, validation and editing formed an operational cycle, in which data were checked and adjusted, checked again, adjusted again, and so on, until the utility could bill customers fairly. Multi-register metering, as a billing basis, also added steps to the billing process. However, at no point were these steps as complex or as prone to error as those in the magnetic tape billing process. In the latter, the opportunities for bad data were many and more checks of data quality were necessary. The editing routines for adjusting the data were sometimes very complicated. They sometimes depended upon such collateral information as time errors due to power outages. Magnetic tape could be lost completely. For this reason there was an increased incidence of

billing on the basis of pure estimation. Since perfection was generally unattainable, it was necessary to establish data quality tolerances for billing purposes. In some cases, small imperfections of consumption measurement and its time distribution had to be ignored. The tolerances adopted by Project utilities were not particularly liberal. Through much hard work the Projects were able to attain their tolerances. After final editing, most Project utilities further monitored the validity of the bill.

TOU billing required more skill than standard billing, and in most Projects some special training was indispensable. This was true even when experienced personnel were involved. Skills for traditional billing operations almost always had to be enhanced for TOU billing. The general work experience of technical and clerical personnel was, however, very important in all the Projects. Without this existing skill level, establishing these complex operations would have been much less feasible.

Given the special equipment, elaborate operations, and a large role for skilled labor, TOU billing was expensive. The cost per customer per billing period was estimated at \$10 in one Project and \$13 in another. A third Project estimated that TOU billing was about twice as expensive as traditional billing. Those who have the experiences of the Projects to learn from may very well be able to reduce these costs.

APPENDIX 1

**SOFTWARE SPECIFICATIONS FOR GRAND RIVER DAM
AUTHORITY'S TRANSLATION SYSTEM**

1. VALIDITY CHECK

Check each field tape for validity of data, if in error the system will re-read five (5) times minimum before advancing or defining an error, and read-after-write check of output tape. Provide parity check detection option for magnetic reader.

2. TIME INTERVAL CHECK

Calculate the correct number of time intervals based on "Start," "Stop," times and compare the number of time pulses translated from the field tape.

3. DATA CHECK

The software shall compare KWH and KVARH totals calculated from total pulses in each channel to the actual meter readings and/or tape recorder register readings, which have been input manually. The software shall compare KW demand with the last previous taped demand.

4. INPUT OF DATA

The fixed data shall be stored in the disk and be accessible to the operator by use of the operator's console (item B-3b). When translating tapes this fixed data shall be protected from being lost from the disk but be capable of being changed whenever any of the fixed data changes.

5. OUTAGE INSERTION

The software and hardware must enable the translator to insert up to six (6) known outages per tape. The corresponding intervals outputted to the half inch computer tape will contain 0's in those interval spans. Pertinent information will be printed regarding the time of day and the day regarding those outages.

6. CONCURRENT DATA ENTRY

After the fixed information (and outage information, if present) are entered, the tape reader shall begin to read the field tapes while the rest of the variable information is entered by the operator's console.

7. FALSE PULSE DETECTION

Any pulses which are found to occur on the field tape time track during the blanking period are considered to be false

and are to be counted but do not cause the data channel pulse counters to dump their counts, which would result in false demand information outputted to the half inch magnetic tape. The interval numbers, where the false pulses were detected, should be flagged and outputted to the half inch computer tape and to the printer output.

8. MISSING INTERVAL PULSE INSERTION

The translator software shall allow for the capability of inserting missing time interval pulses as long as there is validated demand data in the interval channels. The program shall keep track of the time between successive interval pulses as they are translated. All missing pulse insertion intervals shall be flagged and outputted to the tape. The total number of missing pulses inserted shall be indicated on the completion report.

9. RECOVERY ROUTINE

The translator system shall be equipped with the method of disabling the blanking circuit and the missing pulse insertion routine to attempt to recover as much data as possible from those tapes where the time pulses are badly skewed out of place.

10. RECORDER INTERVALS

The translator shall be capable of translating tapes of five (5), fifteen (15), thirty (30), or sixty (60) minute intervals recorded from sixteen (16), thirty-six (36) or seventy-two (72) day durations.

11. DUMP PROGRAM

This program produces an interval by interval pulse listing. The "dump" will be a stand along translation program loaded on after the translation process is completed. The translation system shall query the operator for the tape identification number of the desired tape. More than one tape may be listed in each run of the dump program. This program will allow the operator to select a portion of the tape to dump by entering the location, the date and time of day for the start and stop of the dump. The dump shall handle a valid interval per hour (evenly divisible into 60).

12. KWH AND KVA PEAK ANALYSIS

This program shall be a past translation routine which produces the KWH totaled for all channels, the three highest KW values and the three highest KVA values along

with coincident KVA (KW), KVAR, power factor, and volts if present. KVA calculations may be based on either KW and Q-meters, or KW and KVAR meters, whichever is present. The highest KVA (KW), and its coincident KVAR, power factor and volts if present shall be stored in the fixed data on the disk.

13. COMPLETION REPORT

The operator shall have the option of, (1) having the completion report printed on a high speed line printer when the minicomputer is automatically accepting or rejecting the field tape, (2) having the completion report printed on the high speed line printer when he has the power to accept or reject the field tape, (3) not having a completion report printed when the computer automatically accepts or rejects the field tapes.

The completion report shall compare the number of intervals accepted versus the number translated. A comparison shall also be made of the net meter readings versus the number of translated pulses, both times the proper multiplier. The number of faults and inserted pulses shall be listed with the occurrence times.

This report will clearly and concisely identify the cartridge, the type of cartridge, the date and time it was translated, and additional data which would assist the operator in judging the integrity of the recovered data.

14. DAILY SUMMARY PROGRAM

Translation system must be capable of outputting KW or KVA, pf, volts and amps for a particular day in the following format; The high, the average and the low value for each calendar day requested by the operator. The time of the day of the KW peak must also be reported. The heading for the page must include the account ID (20 alpha numerics), customer name (64 alpha numerics, 2 lines) and the date and time of translation. The data can represent 30 minute data while the recorder interval could represent 5, 15 or 30 minute data.

15. STATUS LIST

At any time during the translation process the system must be able to respond to the operator's request for a status list. This report lists the job table contents regarding what cartridges have been translated, their present status and any request outstanding on that cartridge at the present time. If partial data

files are present the status list also prints the start and stop time of the partial file.

16. ERROR MESSAGE OUTPUT

The translator system must have a single program for the output of error messages. These messages must have a high priority so that any other program will be interrupted by an error allowing the operator to have an immediate feedback as to problems, or possible problems, that may exist with the system.

17. DAYLIGHT SAVINGS TIME

The two changeovers per year for daylight savings time must be carried on a file. These entries may be updated by the operator at any given time. The reports on the translator must take into account the daylight savings change and either add or subtract an hour from the date as reported and so indicate on any printed output. However, the actual raw data in the disk data file must not be changed.

18. LEAP YEAR

The computer must be able to recognize the existence of a leap year and adjust its calendar accordingly.

19. PURGING THE SYSTEM

The translator system must have the ability for purging a translation from the system at any time.

20. SMALLER TIME INTERVAL TRANSLATION PROGRAM

The translation system must also have the ability to be able to study the customer's use of power during the smaller increments of time than those recorded. Readings from the cartridge at some predetermined time increment must be available to all report programs.

21. ROLLING PEAK OPTIONAL PROGRAM

The rolling peak program will allow the system to add together shorter intervals to get extended intervals that overlap, i.e., a five minute data rolled for thirty minute data would examine the time between five minutes after the hour, thirty-five minutes after the hour; ten minutes after the hour; forty-five minutes after the hour, etc. This overlap should roll around the clock to examine all possible thirty minute intervals based

on the five minute interval data. The operator is to have the option of selecting larger or smaller intervals based on the five minute interval. The rolling peak report will appear on the line printer as the cartridges are translated. The values reported by this rolling peak interval program are the interval pulse counts and their associated time--the six high and low values for each channel along with the date and time of occurrence (lesser number may be specified by the operator) and the coincident values in the other recorder channels.

22. MULTIPLE METER PROGRAMS

The translator must be able to accept multiple meter tapes for the same customer providing an output of energy usage which is to be the sum of all the meter net readings. The meters are given an identifying number (8 alpha numeric) and these numbers are stored in the meter file with the account ID of the key. The completion report should generate an additional page which contains the multiple meters, each with its start reading, its stop reading, net reading, multiplier, and extended value, kilowatt hours, KVARH of the net consumption with the associated demand factor. Each meter record for that individual customer must be accessible and must be able to be modified by the operator from the console. This multiple meter program should allow large customers to be billed from a single recorder peak analysis while individual use is preserved by the meters.

23. TOTALIZING PROGRAM

The translator system should have the capacity for totalizing the entire energy consumption of all the translated tapes for particular time interval. The operator should be able to select part or all of the translated tapes for totalizing, the operator should also have the option of selecting the peak or minimum and the associated time and day of month with the option of what amount of the composite peak or minimum value came from each contributor. The translator system shall have the capability of computing a particular time of day and date (up to a maximum of six).

24. COINCIDENT PEAK PROGRAM

Translator system should have the ability to search for a coincident peak from a set of 200 or 500 metering installation tapes when specified by the operator and print out each customer's contribution to that peak.

25. CALENDAR MONTH PROGRAM

The translator system must have the capability of carrying over partial information from a previously translated cartridge. The routine must use a previously established initialization date and cut off date (operator entered) to know how much of a cartridge file to copy into the calendar month file. This program must also allow for the translation and totalization of a customer's tape of length of less than 30 days.

26. SOFTWARE MAINTENANCE

The supplier shall provide a one year software maintenance contract to commence after installation and light off at GRDA's site.

27. VOLTAGE

The translator system must be capable of printing out the voltage for that particular time of day which would be obtained from the volt squared hour meter on one of the three available tracks on the magnetic tape cartridge.

Source: GRDA System Improvements Contract 549, 1977.

APPENDIX 2

LIST OF ELECTRIC UTILITY DEMONSTRATION PROJECTS
AND
LIST OF PERSONS INTERVIEWED

TABLE 1A

Electric Utility Demonstration Project Participants

Project Location	Participants	Performance Period	Key Project Personnel
Arizona	Solar Research Commission (s) Arizona Public Service Co.(u)	6/75-12/76 ^a	James F. Warnock (SRC) Doug S. Windes (DOE)
Arkansas	Public Service Commission (s) Arkansas Power & Light Co.(u)	6/75-9/77	James F. Herden (APSC) Ralph Teed (AP&L) Doug S. Windes (DOE)
California	Energy Resources Conservation & Development Comm. (s) Public Utilities Comm. (s) Pacific Gas & Electric Co. (u) San Diego Gas & Electric Co. (u) Southern Calif. Edison Co.(u) Sacramento Municipal Utility District (u)	7/76-P	Richard M Hairston (ERCDC) Roger Levy (ERCDC) John Flory (ERCDC) Jackalyne Pfannenstiel (Smith) (CPUC) (formerly of Conn. PUCA) Doug S. Windes
Connecticut	Public Utilities Control Auth.(s) Connecticut Light & Power Co. (u)	6/75-3/77	Jackalyne Pfannenstiel (Smith) (Conn. PUCA)

(continued)

TABLE 1A (continued)

Project Location	Participants	Performance Period	Key Project Personnel
Edmond, Oklahoma	City of Edmond Edmond Municipal Electric Co. (u)	12/76-6/78	Paul Buntz (EO) Doug S. Windes (DOE)
Los Angeles California	Department of Water & Power	6/75-9/79	Dennis Whitney (LADWP) Doug S. Windes (DOE)
Michigan	Public Service Comm. (a) Detroit Edison (u)	8/75-12/77	Robert Benko (PSC) Jane Christophersen (DOE)
New Jersey	State Energy Office (s) Jersey Central Power & Light Co. (u)	6/75-5/80	Charles Richman (SEO) Paul Johnson (DOE)
New York	Public Service Comm. (s) Consolidated Edison (u)	1/76-6/77	Joseph Rizzuto (PSC) Doug S. Windes (DOE)

(continued)

TABLE 1A (continued)

Project Location	Participants	Performance Period	Key Project Personnel
North Carolina	Utilities Comm. (s) Carolina Power & Light (u) Blue Ridge Electric Membership Corp. (u)	7/76-8/79	Antoinette Wike (UC) Jane Christophersen(DOE)
Ohio	Public Utilities Comm. (s) Dayton Power & Light Co. (u) Toledo Edison Co. (u) Buckeye Power Co. (u)	6/75-3/78	Robert Wayland (PUC) Jane Christophersen(DOE) Joseph Wathen (PUC)
Puerto Rico	Commonwealth Water Resources Authority (u)	7/76-7/80	Alberto Bruno-Vega (C) Paul Johnson (DOE)
Rhode Island	Public Utilities Comm. (s) Blackstone Valley Electric Co. (u)	7/76-10/78	Thomas Chmura (PUC) Lewis Bailey (BVEC) Christina VanSickle(DOE)

(continued)

TABLE 1A (continued)

Project Location	Participants	Performance Period	Key Project Personnel
Vermont	Public Service Board (s) Green Mountain Power Co. (u)	11/74-1/77	Wayne Foster (PSB) Charles Elliott (GMPC) Larry Kaseman (DOE) Doug S. Windes (DOE)
Washington	State Energy Office (s) Seattle City Light (u) Clark County PUD Puget Sound Power & Light Co. (u)	9/76-10/78	Jacob Fey (SEO) Nancy Tate (DOE)
Wisconsin	Public Service Comm. (s) Wisconsin Public Service Corp. (u)	9/75-11/80	James Simpson (PSC) Jane Christophersen (DOE) Richard E. James (WPSC)

Source: Compiled from Electric Utility Demonstration Project Reports and documents and interviews, 1975-1980

^aProject was completed as far as DOE involvement was concerned. The experimental TOU rates have continued to date.

^sParticipating state or city agency.

^uParticipating utility.

TABLE 2A

List of Persons Interviewed

Name	Address
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Department of Energy Personnel

M. Larry Kaseman	U.S. Department of Energy Economic Regulatory Administration Division of Regulatory Assistance Washington, D.C.
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Steven Mintz	"
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Project Participants and Consultants

Lewis Bailey	Blackstone Valley Electric Company Providence, Rhode Island
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David Bryant	Arkansas Power and Light Company Little Rock, Arkansas
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Neil Dikeman Marge Early	University of Oklahoma Norman, Oklahoma
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Paul Hart Nick Holland Alan Propper	Arizona Public Service Company Phoenix, Arizona
---	--

John Keene	Green Mountain Power Corporation Burlington, Vermont
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Richard E. James	Wisconsin Public Service Corporation Green Bay, Wisconsin
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Jackalyne Pfannenstiel (Smith)	California Public Utilities Commission Sacramento, California
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Dennis Whitney	Los Angeles Department of Water and Power Los Angeles, California
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Billy Yarborough	Carolina Power and Light Company Raleigh, North Carolina
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