R-2037

MASTER

Discussion Series on PURPA Related Topics *

METERING

BILLING

**INFORMATION
TO CUSTOMERS**

**LOAD
MANAGEMENT**

**MASTER
METERING**

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

ABSTRACT

The master metering of electricity was investigated in nine of the Pilot Implementation Projects. In each Project some type of action toward its elimination was taken. This action was taken after several aspects of master metering were studied.

One aspect of master metering which was studied was its effect on conservation. The general conclusion of the Projects was that master metering increased the level of energy consumption by as much as 40 percent in some areas and 11 percent in others. One study of housing units before and after conversion to individual metering showed consumption reductions of 17 and 20 percent.

Two costs of eliminating master metering other than the cost of meters were: 1) the loss of centralized space conditioning and hot water systems and 2) increased building costs. It was found that centralized space heating systems used 10 to 15 percent less energy than individual systems. In one Project it was estimated that construction costs in high rise buildings could increase by around \$3,000 per apartment if master metering was eliminated.

In light of some of the efficiencies some Projects examined alternatives to eliminating master metering. Five alternatives were examined or considered. Among these was submetering of master metered central systems. Submetering was reviewed but the lack of reliable and economical submeters prevented its testing. Another alternative was to bill master metered customers on multiple block rates. This was used in one Project and it eliminated the cost advantage of master metering.

Although alternatives to the elimination of master metering were examined most commission actions were directed at its elimination. Most commissions exempted specific uses such as centralized hot water and central heating and cooling systems. Typically the ban on master metering was for new construction.

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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, Master Metering, relates primarily to the Time-of-Day rates standard, PURPA IB(d)3. The experiences related in this report deal, in part, with the content and methods of providing rate and conservation information to customers when Time-of-Day rates are used.

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 and the Pilot Implementation 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 fifth report on Master-Metering looks at the field experiences in the Projects dealing with Time-of-Use (TOU) rates and conservation.

This volume is not a specialist's manual but an account of field activities involving many aspects of the process of evaluating the master metering of electricity. 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 customer information programs for Time-of-Use rates and conservation.

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 consultants and others interested in assessing master metering. They will be able to assess Project accounts of field experiences, providing a viewpoint which may ultimately aid in design and preparation of master metering projects.

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

Three general observations stand out in this report.

- Most of the Project studies indicated a reduction in consumption between 11 and 40 percent could occur if master metering was eliminated in their state or region.
- Central heating systems, especially in high rise buildings, are much more economical than dispersed ones and their elimination under master metering created increased construction cost and lost efficiencies.
- Commission actions on master metering included holding extensive hearings and investigations. Some commissions ordered bans of master metering in new construction.

CHAPTER : AN OVERVIEW OF MASTER METERING ISSUES
TWO : AND ACTIONS IN THE PROJECTS
:

INTRODUCTION

This chapter presents an overview of the master metering issues examined during the Pilot Implementation Projects: the conservation effect of master metering, and the economics of eliminating master metering. Each of these issues is more thoroughly discussed in Chapter 3. This overview also contains a brief discussion of the alternatives to master metering and the actions taken by the Projects to eliminate or prohibit master metering. Each of these topics is more thoroughly discussed in Chapter 4. This discussion concentrates on master metering of electricity. However, there is some mention of the master metering of natural gas, when such a comparison is relevant.

CONSERVATION AND COST

Master metering, using a single meter to measure gas or electricity consumption in more than one dwelling unit, reduces or eliminates the price signal the final consumer would receive if individual metering were used. Since these price signals stimulate conservation, master metering tends to discourage conservation by removing the stimuli.

In the era of cheap energy, the lower initial costs of master metering, in conjunction with declining block rate structures, allowed substantially less expensive service to customers. Rising utility costs have eroded this advantage; hence, landlords must either pass on utility cost increases (e.g., by raising rents) or suffer loss of profits, if they are to continue to use master metering.

Solid data on master metering have become available only recently (largely because of government's recent interest in it).

Since master metering is relatively infrequent, few cost data exist and comparisons of the two metering practices are not as informative as one would like. Estimates of potential energy savings by substituting individual metering for master metering vary with locale and with the form of energy studied (electricity or gas). The average potential reduction in electricity consumption appears to be between 15 percent and 25 percent, while reduction in gas consumption appears to be between 4 percent and 8 percent. In some cases, conversion to individual gas metering has been accompanied by an increase in total consumption. The consensus appears to be that prohibition of electrical master metering is more effective than prohibition of gas master metering.

Extremes have been reported, however. Testimony in a hearing before the California Public Service Commission reported that a master metered apartment building consumed 89 percent more energy than a submetered building. A study of a single apartment complex converted from master to individual metering found a 32 percent decrease in electricity consumption when two winter months were compared with the corresponding months in previous years. This would suggest that master metering induced 47 percent more consumption than individual metering.

A landlord who pays for the electricity consumed by his tenants, but who is not free to pass on the total cost as it is incurred, might be additionally motivated to invest in insulation, weatherization and efficient appliances. On the other hand, if the tenants are individually responsible for their energy consumption the landlord is probably less concerned about conservation. Tenants are usually less free to use conservation measures because a renter can seldom obtain permission to insulate, or to add storm windows, nor do tenants usually find the cost worthwhile. In other words, individual metering removes the financial obligation from the person responsible for the

efficiency of the building (the landlord) and delivers it to the person responsible for energy use (the tenant). Thus part of the cost-effectiveness of this move depends on whether the consumption level of the building depends more on the behavior of its occupants than on its design, construction, appliance stock, and service systems.

Even though making end-users financially responsible for the energy they consume would effectively reduce consumption, there are a number of questions about the overall cost-effectiveness of complete prohibition of master metering.

An across-the-board prohibition of master metering in new construction makes it difficult, if not impossible, to install such central service systems as hydronic heating, central air conditioning and ventilation, and central domestic hot water supplies. In some cases, central installations may be significantly more energy efficient than dispersed, individualized systems. Thus, the conservation effects of price signals (individual metering) compete with the conservation effects of centralized service systems (master metering).

The connected load of centralized electric service systems is normally much less than that of an equivalent dispersed system. This difference can be very important when the contribution of the total system demand (connected load) is of greater importance than the total amount of energy consumed.

The loss of efficiency (in central service systems) is one effect of the prohibition of master metering. Another important effect is the increased cost associated with purchasing and installing new meters.

If a new building is individually metered, the following new costs fall to the utility:

- In an n -unit building, n new meters have to be purchased, maintained and read.

- (n-1) more customer accounts have to be operated, from meter reading to bill posting.
- Provisions must be made for at least an n-fold increase in the cost of customer nonpayment and service problems.

Rates will eventually reflect these increased capital and operating costs.

The cost to the utility (and ultimately the customer) of individual metering represents one area of additional expense. Another expense is the extra cost of wiring and plumbing multi-family dwellings. This is an important aspect of individual metering cost, especially in high rise apartments.

ALTERNATIVES AND ACTIONS

Some of the Projects looked at or experimented with alternatives to the elimination of master metering. For example, one compromise between the advantages of centralized systems and the need for individual price signals was submetering. In this case, the submeters did not measure electricity or gas: they metered converted energy as it passed from the central system to the individual units. At the present time, however, the required BTU meters, flow meters, temperature sensors, etc., may not be economically available, and the devices that are available may not meet metering standards.

A second problem was that many utilities and regulatory bodies prohibited submetering in order to prevent resale profiteering by landlords. If master metering was to be retained in central service system buildings, to gain the advantages of individual price signals, then the institutional/legal question of submetering needed re-evaluation.

Two other alternatives to the elimination of master metering were either proposed or implemented. One alternative was multiple block rate billing of master metered customers. In this type of billing the energy charge for the first block of

kwh (in a declining block rate structure) is multiplied by the number of units in the apartment building. Thus the initial, high-cost block is shared by most of the sub-units. The technique was proposed in Connecticut and it is used in United Illuminating's service area. It has been fairly successful in reducing the number of master metered dwellings. At the present time only 11 percent of apartments in that area are master metered.

Another proposed alternative to the elimination of master metering was the application of stringent conservation requirements as a condition for installing master metering. The objection to this alternative was that the stringent conditions would have to be closely monitored and would, in effect, turn commissions into "energy police."

Nine Pilot Projects investigated the issues involved in master metering. Each Project was committed, as part of their cooperative agreement with DOE, to eliminate master metering in its jurisdiction. This report summarizes the actions of each Project, with emphasis on the Connecticut, Ohio and Seattle Pilot Implementation Projects, since their investigations yielded a thorough discussion of the whole issue of master metering.

CHAPTER : CONSERVATION AND COST OF
THREE : MASTER METERING

INTRODUCTION

Several questions needed to be answered before formulating a policy on master metering of electricity. This chapter contains a discussion of the attempts of the Pilot Implementation Projects to answer these questions. The discussion focuses upon two primary concerns: 1) the conservation value of the elimination of master metering and 2) economic and institutional impediments to its elimination.

Prohibiting master metering was thought to have implications beyond simple energy-saving. One issue was whether or not individual metering of multi-family residences could save enough energy to offset the cost of conversion or prohibition. This depended upon several factors: 1) what form of energy was used, 2) whether individual metering involved both gas and electricity, 3) whether it was mandatory for new construction only or for existing buildings as well, and 4) whether the master metering in question involved central service systems. A variety of administrative, equity, and welfare issues revolved around the question of whether individual metering was economically justified. The decision process leading to the prohibition of master metering was, therefore, complex.

THE CONSERVATION IMPACT OF MASTER METERING

The first question raised in formulating master metering policy was how the practice actually affected the level of energy consumption. It was generally thought that master metered end-users consumed more energy than individually metered end-users; thus the question was one of economics. It was necessary to determine how much more energy was consumed using master metering instead of individual metering. Also, it was essential that

this measure be more than a grand average of multi-family dwellings: the data must be broken down into a number of categories, such as, apartment size, building construction, space conditioning system, appliance mix, and ideally, certain demographic characteristics of tenants.

The Current Incidence of Master Metering

The impact of master metering on energy conservation depended on how many people consumed master metered energy. Even if the average excess consumption due to master metering was very substantial, the conservation impact of the practice was not, if confined to a small fraction of the service population. For example, in the course of its investigation of master metering practices in the state, the Iowa Pilot Project determined that for the most part the utilities already restricted them, except for shopping malls, and for housing projects denied individual metering by Federal funding requirements.¹

It was estimated that in 1975 one-third of the multi-family dwellings in the United States had master metered electricity, and 90 percent of them had master metered gas.² But the Pilot Projects did not report as high an incidence of master metered electricity as had previously been estimated: master metering was already on the wane by 1977. A report prepared for the Ohio Pilot Project estimated that there were 1.5 million multi-family dwelling units in Ohio, and that about 305,000, or 20 percent, were master metered.³ A study by Seattle City Light estimated

¹Iowa Pilot Project Quarterly Progress Report, January-March 1978.

²Midwest Research Institute, Energy Conservation Implications of Master Metering, Federal Energy Administration (USDOE) October 1975.

³R. W. Beck & Associates, Master Metering Study for the State of Ohio Public Utilities Commission, 1978.

that 14 percent of all new apartment construction and between 11 and 12 percent of the existing multi-family dwellings in the Seattle area were master metered.⁴ A survey of building contractors in Connecticut showed that 80 percent of those either constructing or planning apartment projects had selected individual electric meters.⁵

In the Connecticut Pilot Project one utility was reported to have 296 master metered residential accounts, comprising 10,802 units, or about 11 percent of the service population.⁶

Data on the incidence of master metering was difficult to acquire in localities where utilities did not distinguish master metered accounts in their records, as was the case in Ohio.⁷ However, most utilities were able to make reasonable estimates.

DIFFERENCE IN CONSUMPTION--
MASTER AND INDIVIDUALLY
METERED UNITS

The difference in consumption between master metered and individually metered dwellings was sometimes reported as a proportional excess and sometimes as a proportional potential savings. The two measures were sometimes confused. For example, a 35 percent more consumption under master metering was taken to

⁴Seattle City Light, The Effect of Master Metering on Electric Consumption in the Seattle City Light Service Area, August 1978.

⁵Philip Layfield, testimony before Connecticut Public Utilities Control Authority, Docket No. 780718, General Investigation on Prohibiting Master Metering for Multi-Unit Dwellings, October 1978.

⁶C. W. Cook, testimony before Connecticut Public Utilities Control Authority, Docket No. 780718, General Investigation on Prohibiting Master Metering in Multi-Unit Dwellings, October 1978.

⁷R. W. Beck & Associates, op. cit.

indicate a potential savings of 35 percent if there was a conversion to individual metering.⁸ But if X is 35 percent greater than Y it does not mean that Y is 35 percent less than X. In general, if master metered consumption is P percent greater than individually metered consumption, then individually metered consumption is $P/(P + 100)$ percent less than master metered consumption, and that difference is the real potential savings due to individual metering.

Geographical, economic, and social variations probably cause a broad scatter of the effect master metering has upon consumption. A nation-wide study, prior to the Pilot Projects, found that excess consumption of electricity ranged from 8 percent to 169 percent in master metered dwellings. The average excess consumption was 35 percent.⁹ A later report (1979) estimated the average to be between 18 percent and 25 percent.¹⁰

The Seattle Pilot Project's investigation of master metering in the Seattle City Light service area found that master metered apartment units consumed about 31 percent more electricity than comparable individually metered units. The total excess consumption of electricity ranged from 12 percent to 68 percent.¹¹ Total electric consumption for seven pairs of individually and master metered apartments was compared. The HVAC system, the insulation/weatherization level, age of structure, appliance mix, construction type, vacancy rate, and number of dwelling units were taken into consideration in the pairings.¹²

⁸This problem is discussed in Booz, Allen and Hamilton, Alternative Metering Practices: Implications for Multi-family Residences, U.S. Department of Energy, June 1969.

⁹Midwest Research Institute, op. cit.

¹⁰Booz, Allen and Hamilton, op. cit.

¹¹Seattle City Light, op. cit.

¹²Ibid.

The Seattle Project's study estimated that the average annual consumption for a master metered, all-electric apartment was 11,898 kwh.¹³ The report also estimated that approximately 3,686 kwh per unit per year could be saved by prohibiting master metering. This estimate (3,686 kwh) was apparently made by taking 31 percent of the average annual consumption figure (11,898 kwh): The potential savings from the prohibition of master metering was not 31 percent, however. The 31 percent represented present excess consumption due to master metering.¹⁴

The Ohio Project commissioned a firm of consulting engineers to investigate master metering in the state.¹⁵ Electricity consumption data were obtained for 7,987 apartments, and gas consumption data for 9,053 apartments were also collected. Since about 80 percent of Ohio's multi-family dwellings were in major cities, the sample was drawn entirely from Cleveland, Cincinnati, Akron, Columbus, and Dayton. All the apartment complexes studied had been in operation the entire previous year. Vacancy rates were low and stable.

It was found that individually metered high-rise apartments consumed 40.6 percent fewer kwh per living unit than master metered high-rise apartments. Low-rise apartments gave surprisingly different results. Individually metered units averaged 35.3 percent higher consumption than master metered units. The explanation for this seems to have been that the sample of low-rise dwellings included town houses, which tend to have much higher electricity consumption than apartments. Every town house in the sample was individually metered. Thus the comparison

¹³Ibid.

¹⁴The potential savings was 31 percent/131 percent, or approximately 24 percent. The adjusted potential kwh savings was not 3,686 kwh per unit per year but 2,855 kwh per unit per year.

¹⁵R. W. Beck & Associates, op. cit. All of the following material on Ohio master metering is from R. W. Beck & Associates.

of master metered and individually metered low-rise units included a comparison of non-town house to town house units. This distorted any master metering effect which was present. With town houses removed from the sample, the difference between master metered and individually metered units became insignificant. It turned out that there was no master metering effect. The sample of individually metered low-rise apartments (other than town houses) contained only one bedroom and "efficiency" apartments. Since their electricity consumption did not include space conditioning and water heating, opportunities for significant conservation were minimal.

The individually metered high rise units used 40.6 percent less electricity but the effect was distorted since a sampling error was present; there were no individually metered all-electric apartments. Thus the average consumption of master metered apartments was inflated because of large consumption in all-electric apartments. This was not balanced in the individually metered group. When all-electric units were deleted from the comparison, the individually metered apartments were found to consume 23.4 percent less electricity per unit than master metered apartments. When individually metered consumption in both high-rise and low-rise units was averaged (with all-electric units deleted) there was a potential energy savings of 21 percent.

Comparisons of master metered and individually metered units were made, using seven more subsamples (all high-rise apartments with forced air heat, and all 2-3 bedroom apartments with either gas or electricity heat in high- or low-rise buildings), and in every case individually metered units had a lower average consumption.

The study found nothing in favor of using individual metering for natural gas. Individually metered low-rise apartments averaged 24 percent greater consumption than master metered

TABLE 1

Estimated Reductions in Electricity Consumption
Due to Changing to Individual Metering,
Selected Projects

Project	Percent Master Metered Multi- family Dwellings	Percentage Reduction
Connecticut ^a	11	17-20
Ohio ^b	20	21
Seattle ^c		
Existing	12	24
New	14	

Source:

^aR. W. Beck and Associates, "Master Metering Study for the State of Ohio Public Utilities Commission," 1978.

^bC. W. Cook, Testimony before Connecticut Public Utilities Control Authority, October 1978.

^cSeattle Pilot Implementation Project, The Effect of Master Metering on Electric Consumption in the Seattle City Light Service Area, August 1978.

units; individually metered town houses averaged 61 percent greater consumption. The negative conservation impact of individually metered gas was probably due to its association with individual space conditioning and water heating. It was generally agreed that centralized (and thus master metered) service systems were much more energy efficient than individualized furnaces and water heaters. Apparently no individually gas metered apartments in high-rise buildings were constructed: the sample of 9,053 did not contain one such unit.

Perhaps the best control of variables in studying the effect of master metering upon consumption occurred in situations in which a multi-family dwelling was compared to itself before and after conversion to individual metering. United Illuminating Company (Connecticut Pilot Project) conducted a study like this for a 50-unit complex housing elderly residents. Consumption data for a one year period prior to conversion (from master metering to individual metering) was compared to consumption data for a one year period after conversion. A 20 percent decrease in consumption occurred after meter conversion (with adjustments for weather differences, since the units had electric heat). Another complex of 60 units housing elderly residents showed the (corrected) effect of conversion to be a 17 percent savings.¹⁶ In a study cited during the Connecticut hearing, Pennsylvania Power and Light Company examined two apartment complexes for changes in electricity consumption after conversion from master to individual metering. The respective decreases were 11.3 percent and 23 percent.¹⁷ The same Connecticut hearing testimony also cited a study in which Rochester Gas and Electric Company found that the average monthly gas consumption in a 69 unit "garden" type complex was 8.1 percent less when individual

¹⁶C. W. Cook, op. cit.

¹⁷Philip Langfield, op. cit.

metering was used. In a 56 unit "luxury high-rise" apartment building, the decrease in gas consumption was 4.3 percent.¹⁸

The Ohio Pilot Project's study¹⁹ of a 246 unit complex with very high annual electricity consumption looked for changes in consumption which could be attributable to metering conversion. In the twelve month period after conversion consumption was 30 percent less than in the twelve months prior to conversion. This was a decrease of nearly one million kwh for the one year period. A comparison of the first and second six-month periods showed a waning of the conservation impact of individual metering. In the first six months after conversion, consumption was 40 percent less than in the corresponding six months of the pre-conversion period. In the second six months the decrease was 24.2 percent. The "novelty" effect of receiving utility bills probably contributed to the large drop in consumption during the first six months.

Centralized vs. Dispersed Systems

Apartment builders and landlords have argued that large central water heating and space conditioning systems (service systems) are more energy-efficient, and cost less to construct than individual systems. These economies of scale, it is claimed, more than replace the conservation effect of individual metering. Therefore, according to this argument, individual metering should not be achieved by installing individual service systems in each apartment.

Gas-fired central service systems provide strong evidence to support this argument. One study, cited in testimony at the Connecticut hearing, compared central boilers to individual water heaters, and central hydronic heating systems to individual

¹⁸ Ibid.

¹⁹ The following material on Ohio master metering is from R. W. Beck & Associates, op. cit.

warm-air heaters. Individual water heaters were found to cost 3.5 times as much as the central boilers and they were required to carry 5.3 times the load of a central heater. At an assumed daily consumption of 50 gallons of water at 140°F per unit, the individual heaters would consume 3,173 more BTU's of gas per day per unit than the central system. The rate of energy loss in individual warm air heaters (operation of pilot lights and standby flue losses) would be 293 times the amount of loss in a central hydronic boiler system.²⁰

In the case involving master metering of gas, the California Public Utilities Commission ruled that it was unreasonable to meter apartments individually for water heating purposes, because it was found that individual water heaters would use 70 percent more gas than a central heater.²¹ Nonetheless, in some instances, the master metering associated with central systems fostered such a disregard for conservation that the efficiency advantage was nullified. According to one Project's master metering study, this was the case in Seattle. The study estimated that 72 percent more electricity was used to heat water when housing units had master metering.²²

To assess the effect master metering had upon residential water heating, eight apartment buildings with central water heating were compared with eight buildings with individual water heating. The pairings considered presence or absence of a swimming pool, vacancy rate, approximate unit size, and presence or absence of a central laundry facility. The water heating comparisons were made for a period of two years. They were based upon the conservative estimate that individually metered apartments used 17 percent of the total kwh for water heating. The

²⁰Philip Langfield, op. cit.

²¹Ibid.

²²This and the following material on Seattle master metering are from Seattle City Light, op. cit.

central systems were all separately metered.

The report admitted that connected load for central service systems was much lower than the load for individual furnaces and water heaters. It also acknowledged that central service systems were more adaptable to TOU rates. Disadvantages such as greater system losses, more complicated administration, and the lack of conservation incentive were seen to nullify the advantages.

MASTER METERING, TOU RATES AND LOAD MANAGEMENT EFFORTS

The way master metering was integrated with TOU electricity pricing was probably determined by the storability of the end-use energy. A central service system (for space or water heating) can shift all of its electricity use to off-peak hours because of its great storage capability. Because the TOU pricing issue had much to do with demand and the required capacity to meet demand, the connected load due to centralized service systems was important.

The connected load per unit for electric space heating was estimated to be about 10 to 15 percent less in central systems than in dispersed systems. The connected load for domestic hot water supplies was 4 to 4.5 KW (and in some cases as much as 5.5 KW) for individual apartment units. For a central domestic hot water supply, the average was 1.2 KW per unit.^{23, 24} This means that there was a greater impact on the utility's capacity from

²³ Seattle City Light, op. cit.

²⁴ Perhaps the average electrical load was lower with individually metered, dispersed service systems, because of the price signal effect. However, Seattle City Light (footnote 4) using data from several sources (including a rate analysis in progress in their own service area), found no average load per-unit difference between centralized and dispersed electric water heating systems during the winter months.

individual heating systems. On the other hand, master metering makes TOU pricing practically impossible when the end use electricity cannot be stored.

Some load management and conservation techniques, e.g., solar assists to heating systems and heat recovery devices, were much easier to apply when service systems were centralized and master metered.²⁵

Testimony in the Connecticut hearing stated that the type of metering would make no difference in the use of certain utility-controlled load management techniques, such as power-line carriers, telephone systems, ripple, dedicated wire or radio signalling of appliances. Simpler local controls, e.g., time switches and appliance interlocks, could also be used without regard to the type of metering. Very sophisticated local load controllers, on the other hand, would probably be economical only in facilities ". . . that would approximate a large commercial or institutional customer."²⁶

Forcing Disproportionate Reliance on One Energy Source

One witness in the Connecticut Pilot Project hearing claimed that certain master metering policies could ". . . force an unnatural selection of an energy source," and that this should be avoided.²⁷ If individualized heating, cooling, and hot water systems were forced upon all new construction by a complete prohibition of master metering, this witness held that there might be strong economic pressure on builders to use electricity for these services rather than other energy sources, due to lower

²⁵J. Whiteley, G. Cochran, G. Robertson, R. Calvert, Individual Metering vs Master Metering. (Undated).

²⁶C. W. Cook, op. cit.

²⁷Philip Langfield, op. cit.

construction cost and simplicity. But it was argued that electricity was not necessarily the most efficient source of fossil fuels. (at the generating plant) for these end uses. Hence consumption of fossil fuels might increase under a master metering ban. And the increase could not be offset by the beneficial effects of price signals in individual metering.²⁸ In the Seattle Project it was claimed that a ban on master metering of central electric water heaters created a pressure for builders to install gas-fired central water heaters since master metering gas-fired water heaters was not banned by the ordinance.²⁹

THE ECONOMICS OF ELIMINATING MASTER METERING

If every apartment in the United States were individually metered for electricity it is probable that less electricity would be consumed. This has not been proposed because the elimination of master metering would not, in every case, save enough energy to justify the trouble and expense. Elimination of master metering in a particular circumstance might save energy, but that fact alone is not enough to justify elimination, in the absence of information about the cost.

Costs of Prohibiting Master Metering in New Construction

"Grandfathering" existing master metered buildings was the generally preferred alternative, but there were additional costs incurred by prohibition of master metering in new construction.

²⁸ Ibid.

²⁹ DOE File Document, Seattle Pilot Project: Memorandum, Appel and Calhoun to Vickery, Report and Recommendation on the Adoption of the 1977 Requirements for Electric Service Connection and Prohibition of Master Metering, December 1, 1978.

A group of contractors, architects, and engineers involved in several building projects in the Seattle area submitted a report on the master metering issue to the Seattle City Light Office of Conservation. This report³⁰ estimated that individual metering (rather than master metering) in a high-rise residential building would add \$1,800 to \$2,050 per unit in construction costs. When full indirect costs were added, the figure rose to between \$2,880 and \$3,280 extra per unit. The larger figure was partially due to an assumption that individualized service systems must accompany individualized metering. The report cited a newspaper article that suggested that 2,000 potential buyers were eliminated by every \$100 added to the cost of a dwelling unit. The total effect of the projected cost additions would be to "eliminate 57,600 to 65,000 prospective homebuyers."³¹

According to this report, the individual incentive in price signals is small, and the extra cost per unit required by individual metering could be better invested in energy efficient equipment. The report further argued that this kind of an investment would have a more predictable effect upon energy reduction than consumers responses to price signals. Decreased building operation fees could also motivate residents to conserve.

Some distinctions between high-rise and low-rise apartment buildings were made in this report. For example, it was stated that the difference in cost between master and individually metered units was not significant in buildings of up to four floors, but when the buildings had more than seven floors, individual metering costs more. Twenty or thirty floor high-rise buildings containing 100 to 130 units per building could have a master/individual meter cost differential "significant enough

³⁰The following material on construction costs related to individual metering is from Whiteley et al., op. cit.

³¹Whiteley et al., op. cit.

to prevent construction."³²

A potential equity problem in individually metered condominiums arose from the fact that in a large, multi-story building, the owner of a ground-floor unit could pay only the same distribution charge as a single-family home owner, but the owner of a unit on the thirtieth floor would pay for additional distribution from the street to the thirtieth floor. Additionally, the individual resident's extra costs for meter, distribution, and contractor's fees were estimated at between \$750 and \$1,000.

The report stated that plumbing costs increased significantly when individual water heaters replaced a central tank. One reason for this increase was the difference in installation costs between vertical piping and horizontal piping. According to the report, "repetitive floor-to-floor vertical piping requirements can be mass-produced in a jig, prior to need, rigged to the floors in pre-packaged bundles, and quick-fastened into place with a minimum of in-place labor."³³ This routinized, prefabricated approach to plumbing is not feasible in high-rise buildings with dispersed water heating systems because horizontal piping is required. It was also reported that high-rise buildings need pressure boosting pumps to lift water to the top floors. There would be a risk of overpressure from this process if individual tanks were fed. The "corrosive, active" cold water supply of the Seattle area shortens the life of heater tanks; frequent replacement or maintenance of many individual tanks would be much more expensive than replacement or maintenance of a single central tank. The probability of leaks is higher in a dispersed system of individual heater tanks, and there is an increased likelihood of damage to other apartments from a hot water leak

³² Ibid.

³³ Whiteley et al., op. cit.

in one apartment. In order to solve this problem a leak pan and drain system would have to be installed at an additional cost. The extra costs of plumbing labor and fixtures would be about \$550 per unit and a waterproof floor or floor drain would add even more. Individual tanks would consume about ten square feet of floor space per unit. Using current construction costs of \$60 per square foot, building an apartment with its own water heater would cost \$600 more.

Saving 35 percent of the energy used for hot water heating in the Seattle City Light study would have amounted to a savings of 4,000 kwh per year. At 2.5¢ per kwh this would have yielded a savings of \$100 per year. The report compared this savings to the additional estimated cost of between \$2,880 and \$3,280 of an apartment with individual water heating. This additional cost was treated as a thirty year mortgage at 10 percent interest. For example, if an extra cost of \$3,000 were amortized at 10 percent per year, the annual cost would be \$315. To this was added the replacement cost of the water heater, amortized on an eight year basis, which was \$50 per year. If maintenance is regarded as 1 percent of capital cost, it would be \$30 per year. If all these costs are added, the result is that the \$100 per year savings due to price signal availability costs the customer \$395 per year.

Costs of Converting from Master to Individual Metering

The per unit cost of replacing a master meter with individual meters varied from study to study. One study reported costs between \$100 and \$1,000 per unit.³⁴ The Seattle City Light study cited significant differences in building structures as the cause of this variation. The extent of rewiring, the accessibility of

³⁴Midwest Research Institute, op. cit.

old wires, the size of the complex, its type of construction, and the remodeling or conversions going on at the time of retrofit all had an influence on retrofit costs.³⁵ A large builder of apartment complexes in Atlanta converted all of its units from master to individual meters and adopted individual metering for all new construction. The initial cost per unit for converting the existing units was \$75 to \$80 (1976). The firm risked an additional cost by promising to pay tenants one-half the difference between a pre-set limit and any electric bill exceeding that limit.³⁶ At the other extreme, in Connecticut the cost of converting a 1,110 unit complex from master to individual metering was \$920 per unit.³⁷

The Ohio master metering study³⁸ projected both the cost and the overall economic impact of converting existing buildings to individual metering. It was estimated that there were 305,000 master metered apartment units in Ohio. The average consumption per unit was 3,592 kwh per year. Thus the estimated annual consumption in master metered apartments in Ohio was just over 1 billion kwh. The decrease in consumption from converting to individual meters was estimated at 21 percent of this amount, or just over 232 million kwh.³⁹

In order to estimate the dollar value of this impact, the study applied parameters of apartment electricity consumption for master and individually metered accounts to six utility rate

³⁵Seattle City Light, op. cit.

³⁶Philip Langfield, op. cit.

³⁷C. W. Cook, op. cit.

³⁸The following material on costs of conversion to individual metering in Ohio is from R. W. Beck & Associates, op. cit.

³⁹The consumption data were gathered during the survey stage of the Project.

structures to arrive at an "Average Aggregate Unit Cost" per kwh. This cost was \$0.03662 per kwh for master metered units and \$0.05368 per kwh for individually metered units. The fuel cost adjustment in both rates was \$0.01352 per kwh.

Projected annual savings to building owners in utility bills (1,095,560,000 kwh X \$0.03662)	+ \$40,119,407
Tenants' losses in utility bills	- \$46,459,632
Utilities' losses from apartment owners	- \$25,331,500
Utilities' gains from tenants	+ \$34,691,000
Utilities' net gains in revenues	+ \$ 9,360,300
.....	
Utilities' net cost of conversion including capital cost and operation and maintenance expenses	- \$16,104,600
Minus net gains in revenues	+ \$ 9,360,300
	- \$ 6,744,300
Utilities' savings in fuel costs	+ \$ 3,134,000
Net economic impact on utilities	- \$ 3,610,300

The total economic impact is

Cost to tenants	- \$46,459,632
Impact on utilities	- \$ 3,610,300
Savings to owners	+ \$40,119,407

Total Economic Impact = - \$ 9,950,525

According to testimony in the Connecticut master metering hearing, there are some problems associated with the conversion to individual metering over and above those of direct cost. Some of these apply to the prohibition of master metering as well, but in general the problems would be more serious in the conversion process.

There would most likely be an increase in the incidence of bad debts when the financial responsibility for utility bills was transferred from landlords to tenants, a group which is more

transient and which contains a significant proportion of low income people. This transience increases the possibility of defaults when tenants move. Poverty also increases the risk of default. The utility's differential losses from these factors would eventually fall upon customers as rate increases. These increases would have a disproportionate effect on the poor. In order to protect itself from such losses the utility would most likely require security deposits as a condition of service.

Another problem is that under complete individual metering of residential units, regulatory agencies would likely experience an increased workload in the form of customer complaints about bills, deposits, rates, and refusal of service. Theft of service cases might also increase.

There would have to be some expansion of public assistance for tenants unable to pay for their own energy costs.⁴⁰

The poor have a special objection to converting their dwellings from master to individual metering. A letter to Connecticut's Public Utilities Control Authority from a group representing low income families remarked that conversion to individual metering in public and "tenement" housing would lead to the landlords' neglect of roof repair, insulation and window repair. The premise was that in many cases heating and utility costs motivated such building care, and if tenants assumed financial responsibility for utility costs, their substandard tenement buildings "would deteriorate even more rapidly than they are now doing."⁴¹ Another tenant group made the same point in a letter to the PUCA and expressed doubt that rents would decrease enough to compensate for utility bills.⁴² These misgivings might also apply somewhat

⁴⁰C. W. Cook, op. cit.

⁴¹DOE File Document: Fernandez to Butterworth, October 23, 1978.

⁴²DOE File Document: Perry to Butterworth, November 14, 1978.

to the prohibition of master metering in new construction, especially if the buildings in question are intended to house low income families.

A possible effect of requiring meter conversion, mentioned in some Connecticut hearing testimony, is an increase in the number of landlords who abandon older buildings rather than convert them.⁴³ As an example of economic pressure not to convert, a hearing witness testified that retrofitting individual meters could in many cases lead to an upgrading of overall wiring and actually increase consumption, by making more end uses possible.⁴⁴ A letter from a property manager to the PUCA noted that once a permit for individual metering conversion was obtained, the entire wiring of the structure would have to be brought up to building code specifications.⁴⁵

SUMMARY

One of the first tasks in most of the Projects was to establish the amount or incidence of master metering in the state. Obviously, the impact of master metering depended upon the number of people who were consuming master metered electricity. Most of the Projects did not report as high an incidence of master metering as had been expected. A report prepared for the Ohio Pilot Project reported that about 20 percent of the state's multi-family dwellings were master metered. United Illuminating, a Connecticut utility, reported that about 11 percent of its service population had master metering. Seattle City Light reported that 11 to 12 percent of its multi-family dwellings were master metered.

⁴³C. W. Cook, op. cit.

⁴⁴Ibid.

⁴⁵DOE File Document: Letter, Justerer to Connecticut Public Utilities Control Authority, November 21, 1978.

Another task was to attempt to establish the effect of individual meter conversion upon consumption. In Seattle City Light's study a potential energy savings of approximately 24 percent was reported. Ohio reported a number of findings depending upon the type of dwellings studied. The potential savings ranged from 21 to 40 percent. A study in Connecticut compared electricity consumption before and after the conversion to individual metering in a 50-unit complex. The adjusted savings was 17 percent.

After determining the potential savings, the Projects tried to establish the cost of conversion. There were, of course, the costs of additional meters and customer account expenses, but other important cost areas included loss of scale economies in central heating and hot water heating systems, and increased building costs for wiring and plumbing. A study cited in Connecticut found that individual water heating required about 3,173 more BTU's than a central system.

A report in the Seattle Project stated that building costs, especially in high rise apartments or condominiums, would increase if master metering were prohibited. Their estimate of increased costs for a high rise residential building was between \$2,880 to \$3,280 per unit. Another study in the Seattle Project estimated that the cost of converting to individual metering in existing structures would range between \$100 and \$1,000 per unit.

A report in the Ohio Project estimated the total economic impact of converting all existing buildings to individual metering: Cost to tenants + Impact on utilities - Savings to owners. The net of this was a cost of almost 10 million dollars.

CHAPTER :
FOUR : ALTERNATIVES AND COMMISSIONS ACTIONS
:

INTRODUCTION

This chapter presents a discussion of some alternatives to the elimination of master metering. Five alternatives were examined during the Projects: 1) take no action at the commission level, 2) define a central service system as a single end use and require end uses to be individually metered, 3) employ submetering, 4) develop multiple block rate structures, and 5) require stringent conservation before granting an exception.

The chapter also contains a discussion and summary of the actions taken by commissions regarding master metering. These actions almost uniformly included a policy of severely restricting master metering except for specified uses or in unusual circumstances.

ALTERNATIVES TO COMPLETE PROHIBITION
IN NEW CONSTRUCTION

There was almost a consensus among the Projects and those contributing to the Projects that buildings already master metered should be exempted from any ban of the practice. The remaining debate primarily concerned the degree of master meter prohibition that should be applied to new buildings.

The alternatives considered in the Projects or suggested by witnesses in hearings associated with the Projects were:

1) for the regulatory body involved to do nothing at all about master metering, but leave the question up to the utility company's policy regarding conditions of service.

2) for the regulatory body to require only that all end uses of the utility-sold energy be individually metered, and to define each central service system as a single end use.

3) To require the submetering of master metered energy. A submeter is a gas or electric meter, or a meter of converted energy (such as hot water), between the master meter and the individual apartment. The building owner would own and maintain the submeters, pass the capital, operation and maintenance costs on to the tenants, and charge each tenant for the energy consumed in his or her dwelling unit.

4) To bill master metered customers (landlords) on multiple block rate structures, which eliminate the cost advantages of master metering.

5) To require that energy be sold to master metered customers only on condition that stringent conservation measures and energy efficient end uses be employed.

The most obvious alternative to the prohibition of master metering was, of course, to do nothing at all. The energy savings under individual metering were large enough and reliable enough to make this alternative unacceptable in many localities. However, the incidence of master metering (in terms of apartment units) was, in some instances, so low that regulatory action would actually have cost more than the amount saved. Arguments to this effect were indeed put forward during metering deliberations in some Pilot Projects,^{1,2} and one Project (Iowa) decided that residential master metering was already adequately suppressed by utility company policies.³

Another alternative to the complete prohibition of master metering concerned the use of centralized service systems (heating

¹C. W. Cook, op. cit.

²Ohio Pilot Project Stage 2 Final Report, July 1979. The argument here was from gas utilities who (correctly) reviewed R. W. Beck's Study which showed no conservation-based warrant for individual gas metering in Ohio.

³Iowa Pilot Project, op. cit.

and domestic hot water supplies). The use of these systems required a slight redefinition of "individual metering."

It had been proposed that all end use energy be individually metered.⁴ Since central service systems are end uses of the sold energy (whatever form it may be converted to by the central system), such systems would qualify as individually metered. Thus the efficiency and economy of scale of central service systems would be retained while the price signal potential would be present wherever the utility's energy was sold. The operator of a central service system for apartment dwellers would have to respond to these signals either by passing them on to the tenants (e.g., by way of submetering) or by instituting conservation, efficiency, and load management measures.

The submetering of electricity does not normally require the same renovation of wiring that is necessary in individual meter conversion.⁵ In fact, there are government housing facilities in Connecticut with submetering facilities already in place. These were installed prior to the ban of the practice. Past abuses of submetering (especially in government controlled housing) such as profiteering, exorbitant deposit requirements and inaccurate meters were not believed to be a problem, according to testimony in the Connecticut hearing. The resale of submetered energy should be rigorously excluded from submetering applications.⁶

Another application of submetering is to meter the converted energy from a central service system, such as a closed loop hydronic space heating system or a domestic hot water supply. The general principle of such metering is that the rate of flow of a fluid multiplied by the difference in temperature between

⁴Philip Langfield, op. cit.

⁵C. W. Cook, op. cit.

⁶Ibid.

outflow and return is a measure of the energy transferred. Such metering would seem indispensable where it was desired to retain both the efficiency of centralized systems and the price signal effects of individual consumption records. The major impediment to its use appears to be that economical meters of the requisite accuracy, stability and durability were not available.⁷

Seattle City Light reviewed the technology which would be needed if master metered central service systems and submetered converted energy systems were retained.⁸ The Kohlenberg flow-meter, a prototype device for measuring the energy transferred by hot water, was developed for the Washington Demonstration Project. Parts for the flowmeter cost nearly \$200. Although it was not in production yet its market price was estimated to be between \$200 and \$400. One problem with this device is that it assumes the ground water temperature rather than measuring it. This could be accounted for by using a BTU flowmeter (\$600) which uses a capillary tube temperature probe. However, the probe's maximum length is 31 feet. Many retrofits would probably be impossible with this device. The device could be removed from the BTU computer and used as a simple flowmeter. If one assumes roughly constant temperature in all branches of a hot water heating system, then simple flowmeters could be used as a fairly accurate measure of the amount of energy each branch (apartment) consumes per unit time. Another kind of flowmeter (\$240) uses a photoelectric sensor which is inserted into the pipe. It has the disadvantage of causing rather large pressure drops across the sensor.

The Seattle City Light Master Metering Report did not recommend hot water flow meters, as their installation required cutting

⁷Philip Langfield, op. cit.

⁸The following information on types and costs of meters for converted energy is from Seattle City Light, op. cit.

pipes and could easily have involved tearing out walls, re-plumbing, wall restoration, and refinishing. Since journeyman plumbers are paid about \$12 - \$13 per hour, and journeyman carpenters about \$11 per hour, these costs would have been prohibitive. Steam or hot air flow measurement was very expensive (about \$2,000 per meter) according to the same report.

Billing at multiple block rates is one method of removing the customer's advantage when master metering is used.⁹ Suppose that a ten-unit apartment building is master metered and charged for its total kwh consumption according to a declining block tariff as follows: 0-300 kwh, 2¢ per kwh; the next 500 kwh, 1.5¢ per kwh; all kwh above 800, 1¢ per kwh. If the building consumes 6,000 kwh in one billing period, then its energy charge would be:

$$(300 \text{ kwh} \times 2¢/\text{kwh}) + (500 \text{ kwh} \times 1.5¢/\text{kwh}) + (5,200 \text{ kwh} \times 1¢/\text{kwh}) = \$62.50.$$

But if each tenant were individually metered, and had consumed 600 kwh of the total 6,000 kwh, the total energy charge to the building would be:

$$10 \times (300 \text{ kwh} \times 2¢/\text{kwh} + 300 \text{ kwh} \times 1.5¢/\text{kwh}) = \$105.00.$$

If such a formula were applied, it would have involved billing the landlord according to a declining block rate structure in which each block was ten times the size of the standard block. Thus multiple block billing is an extension of each block by a multiple equal to the number of units served by the master meter.

According to testimony in the Connecticut Pilot Project hearing, at least one Connecticut utility regarded multiple block billing as an equitable substitute for the elimination of master metering, and an effective deterrent to its institution in new buildings.¹⁰ This witness also reported that the proportion of kwh consumed by master metered apartments in his company's

⁹C. W. Cook, op. cit.

¹⁰Ibid.

service area was not much different from the proportion of all residential units represented by these apartments. This means that the average consumption in a master metered apartment was nearly the same as the service area average for residences. According to the utility this was an indication that some conservation practices had been employed by master metered end users. The utility gave some credit for this to their multiple block billing practice.¹¹ According to other testimony in the same hearing, the primary effect of multiple block billing would be punitive (of master metering), since end users still received no price signals. The punitive effect could be seriously multiplied if units of the apartment building were vacant, and the blocks were nonetheless extended by the full number of units.¹² This effect would have been particularly severe for new apartment buildings, whose units would not typically be occupied all at once. The Connecticut utility mentioned above had a provision for reducing the block multipliers by the number of vacant units, during the first six months of operation of new apartment buildings.¹³

Instead of prohibiting master metering, a utility might have required customers who wanted it to institute certain energy efficient measures as a condition of service. The anti-conservation effect of the master metering would then have been nullified by adequate insulation, weatherization, energy efficient appliances, load management, etc. A report submitted in the Seattle City Light hearing on master metering described a newly constructed high rise apartment building in the Seattle area that had double pane windows. It was estimated that these windows alone would save 237,000 kwh per year or \$55 per unit per year.¹⁴

¹¹Ibid.

¹²Philip Langfield, op. cit.

¹³C. W. Cook, op. cit.

¹⁴Whiteley et al., op. cit.

The main problem with the "conditions-of-service" approach was enforcement. It was claimed that these measures would turn utilities into "energy police" and that making sure that conditions of service were complied with "would probably be an unreasonable burden to place on either the state or the utilities."¹⁵

The United Illuminating Company representative at the Connecticut hearing suggested that stringent efficiency measures should be required of appliance manufacturers instead of master metering customers. The latter course, according to this witness, involved making ". . . objective judgments with respect to a specific customer's use of energy relative to other customers as a condition of service," a task deemed impossible by this witness because of the variability of adequate conservation from installation to installation.¹⁶

COMMISSIONS ACTIONS REGARDING MASTER METERING

The cooperative agreements between DOE and the nine states or municipalities that established the Pilot Implementation Projects all involved the prohibition of master metering. This practice was determined to have a negative effect on conservation.

The regulatory agencies' policies regarding metering varied a great deal from Project to Project, since almost every relevant factor varied from jurisdiction to jurisdiction. Table 2 summarizes the Projects' actions.

The Ohio, Connecticut, and Seattle Projects' reports present a fairly detailed picture of the actual process by which a master metering policy was determined.

¹⁵Seattle City Light, op. cit.

¹⁶C. W. Cook, op. cit.

TABLE 2

SUMMARY OF COMMISSION ACTIONS ON MASTER METERING
IN THE PILOT IMPLEMENTATION PROJECTS

Pilot Project	Action Taken
California ^a	Concerned only with gas metering. Master metering banned in new construction. Utilities ordered to encourage conversion.
Connecticut ^b	Hearing and draft order prohibiting master metering of electricity. State building code modified to ban master metering in new construction.
GRDA ^c	Revised standard contract to forbid resale of electricity, eliminated master metering from all rate structures.
Iowa ^d	Determined master metering much restricted by utilities. Banned it in new construction, statewide, after hearing.
Minnesota ^e	Statewide ban in new construction prior to Project.
Springfield, Mo. ^f	Ban in new construction prior to Project. Central hot water supplies exempt.
North Carolina ^g	Statewide ban in new construction prior to Project.
Ohio ^h	Commissioned large scale study of master metering in state. Draft version of statewide ban in new construction, to be approved by Commission.
Seattle, Wash. ⁱ	Performed study of master metering in service area. City Council banned master metering in new construction by ordinance. Seattle City Light held hearing, incorporated ban into service requirements.

Source:

^aCalifornia Pilot Project First Year Report, March, 1979.^bConnecticut Pilot Project Quarterly Progress Report, April-June, 1979.^cGRDA Pilot Project Quarterly Progress Report, July-September, 1978.^dIowa Pilot Project Quarterly Progress Report, January-March, 1978, and telephone interview.^eMinnesota Pilot Project Quarterly Progress Report, April-June, 1979.

(footnotes cont.)

(footnotes to Table 2 -- continued)

^fSpringfield Pilot Project Year End Report, September, 1978.

^gU.S. Department of Energy Pilot Utility Implementation Program Fact Sheet, November, 1977.

^hOhio Pilot Project Stage 2 Final Report, July, 1979.

ⁱDOE File Document: Letter, Calhoun to Kaseman, February 8, 1979.

The Ohio Pilot Project, conducted by the Public Utilities Commission, was committed to a statewide policy of reducing master metering as much as possible. The Commission's interest lay in determining the incidence of master metering, the costs and benefits of prohibiting it in new construction, and the value of converting existing buildings to individual metering.

When the Project began Ohio had no statewide policy on master metering. The Commission polled a number of utilities regarding their individual policies on the issues. Only two out of the eight selected utilities had restrictions on master metering. Three of the eight reported either the prohibition of sub-metering, or restrictions on it. Five of the eight were unable to distinguish their master metered accounts from others. The need for the Commission to establish a uniform policy on master metering was evident. The results of the study indicated that a policy of restriction would be best.

The Commission considered several alternative means to achieve this end, including

- 1) Using rate hearings on a case by case basis;
- 2) Persuading all utilities to incorporate a single master metering policy into their petitions for rate increases and other utility-initiated matters to be considered in hearings;
- 3) Holding a generic hearing on the issue of master metering that would involve all utilities and result in a comprehensive ruling;
- 4) Doing nothing: that is, allowing market economics to reduce the incidence of master metering to an appropriate level.

The major difficulty with the first alternative was that Ohio laws made it all but impossible for the Commission to introduce new subject matter in a rate hearing. The utility involved would have had to initiate the master metering issue.

This led to the second alternative: a pre-negotiated arrangement whereby each utility asking for a hearing invited a ruling on master metering in the course of its hearing.

The problem with this alternative was that a complete consensus (among all utilities) on master metering would be needed. This was most unlikely. The third alternative, the generic hearing on the issue, would be the most direct approach to the goal, but it would also be time consuming and very expensive. The last alternative, inaction, was a serious consideration only if there were ". . . several mechanisms already in the market limiting master metering."¹⁷

Seeking help in selecting the best alternative, the Commission sent each major utility in Ohio pertinent sections of its report, presenting the alternatives. Most Ohio utilities responded, and most of these agreed with the study's general conclusions. Most also felt that the Commission should take some action, although some gas utilities felt that no case had been made for prohibiting the master metering of gas. A majority of the utilities favored the generic hearing alternative.

At the time of the Ohio Pilot Project's last report on the master metering issue, a model tariff had been drafted. This was to be the subject of a generic hearing in the near future.¹⁸

The Connecticut Public Utilities Control Authority held a hearing on the general issue of master metering of both electricity and gas. The following questions were discussed:

1) Does master metering eliminate accurate price signals to customers?

2) Does the practice interfere with the application of load management or other energy-saving technology?

¹⁷Ohio Pilot Project, op. cit.

¹⁸Ibid.

3) Would its prohibition have a conservation effect, or would it assist conservation measures?

4) Was its prohibition technologically feasible in new construction and in the conversion of existing dwellings to individual metering?

5) Were there practical alternatives to eliminating master metering, as far as conservation was concerned?

6) Would the prohibition of master metering be cost-effective?

The utilities ordered to participate in this hearing were required to develop plans "of how the prohibition could be implemented, and the time required for implementation."¹⁹ Further questions addressed in the hearing had to do with the impact the utilities' plans of prohibition had upon the ultimate users of energy, the development of multi-unit dwellings, the utility itself, the regulatory body (PUCA), and energy conservation.

The hearing was intended to result in an order "regarding the availability of electric and gas service to new multi-family dwelling units."²⁰

A follow-up study was planned to monitor progress in the elimination of master metering, and evaluate the results. This information could be used in reviews and, if necessary, revisions of the program. The follow-up study monitored and evaluated

1) how quickly master metering was reduced.

¹⁹Connecticut Public Utilities Control Authority, Proposal to Undertake Pilot Demonstration Projects, volume I, Technical Approach, September, 1977.

²⁰Ibid.

- 2) problems arising from the different strategies of implementation
- 3) the impact on KW, KWH, and MBTU consumption
- 4) the construction costs incurred
- 5) the incidence of installation of load management services
- 6) interaction of the master metering variable with rate reform and load management practices
- 7) the total amount of conservation
- 8) the profitability and rents of units with and without master metering
- 9) interaction between educational/promotional material (conservation) and the master metering variable.²¹

While the hearing and order writing phase of the Project's master metering activity was ending, the State of Connecticut amended its building code to require separate metering of all new multi-family dwellings "to determine the energy consumption by each tenant." This action more or less obviated the Commission's intention.²²

The Seattle City Council passed an ordinance prohibiting master metering of electricity in new apartment buildings.²³ However, it was recognized that central heating systems were generally more energy efficient than dispersed systems, and that these installations typically constituted only a fraction of the connected load of equivalent installations of individual furnaces or water heaters.²⁴ On the other hand, since central systems promoted higher consumption, their use conflicted with

²¹ Ibid.

²² Connecticut Pilot Project Quarterly Progress Report, April-June, 1979.

²³ Seattle City Light, op. cit.

²⁴ Seattle Pilot Project Third Quarterly Report, June 30, 1978.

the Council's mandate for energy conservation.²⁵ Submetering of the energy converted by central systems was proposed as a compromise: the lower connected load of central systems could be retained, and the profligate consumption allowed by straight master metering could be reduced.²⁶ This proposal raised the important legal issue of whether Seattle City Light could require the metering of energy it did not sell, that is, the hot water exchange medium between the boiler and the individual apartments. The City's Law Department issued the judgment that the submetering of converted energy need not be construed in this way. As long as the end users of the central heating system were customers of Seattle City Light the utility could fairly and legally require submetering in order to apportion the charge among them. Since their non-heating electricity was to be individually metered, this requirement was already met. Also, since the consumption of heat by way of hot water was (in principle at least) a faithful measure of the electricity used to heat the water, the other requirement could also be met.²⁷ The technical and economic problems of obtaining meters for this purpose were insurmountable, however. The final wording of the ordinance, as passed, did not mention submetering of converted energy.²⁸

The Iowa State Commerce Commission held a "show cause" hearing on master metering.²⁹ Utility participation was high, but few individuals or customer groups participated. The issue was not generally considered controversial, most Iowa

²⁵Ibid.

²⁶Ibid.

²⁷Ibid.

²⁸Seattle City Light, op. cit.

²⁹The following material on the Iowa Project is from a telephone interview with Robert Latham, Iowa State Commerce Commission, December 1980.

utilities already having policies against the practice. Some gas utilities in Iowa, as in other localities were opposed to a requirement of individual metering.

The outcome of the hearing was a regulation prohibiting electric and gas master metering in all new construction--residential, commercial and industrial--as of 1 January, 1979. The only exceptions were (1) central HVAC or domestic hot water systems; (2) buildings where individual metering was "impractical, unreasonable, or uneconomic," (3) where submetering of electricity for resale had been practiced since before July of 1966; (4) where master metering of electricity for resale as an unspecified portion of rent was in place before January 1, 1979. Examples of exceptions in Category (2) are retirement or nursing homes with small rooms and central dining facilities. Two or three such exemptions have been granted out of about five applications. Close cost-benefit study preceded each decision.

SUMMARY

Most of the practical deliberation in the Projects concerned alternatives to total prohibition of master metering in new construction, including allowing individual utility policy to regulate the practice, exempting central service systems, requiring submetering, billing on multiple block rates, and requiring conservation measures as conditions of service.

Submetering is an attractive alternative which provides at least two advantages: 1) construction and retrofit costs are lower, and 2) central system efficiency is retained and price signals are available to end users; and two disadvantages: 1) possible profiteering by landlords in the resale of electricity or gas and 2) the prohibitive cost of adequate meters to submeter converted energy. These devices probably cost between \$240 and \$600 each.

Multiple block billing is probably an effective deterrent to new master metering, and it could have a conservation effect because of the sheer high cost of energy it induces. However, it provides no price signal to end users, and it can put landlords in a severe squeeze between utility costs and limits to rent increases.

Since energy efficient building design and construction and energy efficient end uses can save substantial utility costs, master metering might be allowed in structures which incorporate these features. However, if conservation measures and energy efficient features become a part of the utility's requirements for service, then the problem of enforcement arises.

While all Pilot Projects were concerned with the elimination of master metering to one extent or another, the actions taken varied considerably. Several did very little, as the practice was already banned in new construction by statute or ordinance. Others conducted rather elaborate investigations of master metering in their jurisdictions.

CHAPTER :
FIVE : SUMMARY
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The process of examining master metering raises several questions, and data were gathered to answer them. Some of these answers helped to formulate commission or utility policy toward master metering.

One of the first questions regarded the incidence of master metering in the Project's area. Some of the data were surprising. The incidence of master metering was expected to be much higher than it actually was. For example, in 1975 it was estimated that one-third of the multi-family dwellings in the U.S. had master metered electricity. However, the highest incidence of master metered electricity in the Projects was in Ohio, where it was estimated at 20 percent. A Connecticut utility reported that about 11 percent of the dwellings in its service area had master metered electricity. Seattle City Light found that between 11 and 12 percent of existing multi-family dwellings and 14 percent of new apartments in the Seattle service area were master metered.

In general the Projects found that consumption of electricity was higher when it was master metered than when it was individually metered. The estimated increase in consumption ranged from 8 to 169 percent, with an average of about 35 percent.

A number of the Projects studied the effect of the conversion from master to individual metering upon consumption. Most of these studies involved comparing master metered apartments to individually metered ones. The results indicated a wide variety of consumption patterns. For example, master metered apartments in high-rise buildings used less electricity than individually metered ones. However, the opposite was the case in low-rise

apartments. Another study compared consumption before and after individual meter conversion in the same complexes. The results showed a decrease in consumption of 20 percent in one complex and 17 percent in another.

While nearly all of the Projects found that eliminating master metering would reduce consumption, they also found some significant costs. One such area was the loss of economies of scale in centralized heating and hot water systems. One study indicated that it would take as much as 70 percent more energy to individually meter hot water in multi-family dwellings. A study in the Seattle Project found that a central electric space heating system would have a connected load of 10 to 15 percent less than dispersed systems.

Eliminating master metering also increased construction costs. These costs were between \$2,880 and \$3,280 more per unit in a high-rise apartment building in the Seattle area. These increased costs were due to: 1) the need for more wiring and plumbing, 2) the need to provide space in each unit for a hot water and heating system, and 3) the interest on these additional costs which were included in the mortgage.

Aside from the direct costs of eliminating master metering there were a number of equity and institutional considerations. For example, the poor might be at a disadvantage because under individual metering the landlord would be less likely to invest in additional insulation and might even neglect repairs that would otherwise be made.

When master metering could not be eliminated at a low enough cost, alternative means of conservation were considered. In cases where the total effect of master metering upon consumption was thought to be sufficiently small, no action by the commission seemed the best alternative. Where energy efficiency, construction economy, and central heating system longevity were

important, it was proposed that they be exempted from the master metering prohibition. Where these advantages and the price signal benefits of individual metering were possible, submetering with energy allocation devices was considered.

Other alternatives included billing schemes which eliminated all cost advantages of master metering to customers, and service requirements for master metering that incorporated very strong conservation measures. Such proposals had some disadvantages: 1) stringent service requirements posed enforcement problems, 2) punitive billing schemes could inflict inescapable financial damage upon building owners, 3) the price of many energy allocation devices was prohibitive, and 4) central heating systems could foster excess consumption. However, master metering effects on consumption were usually too large to justify taking no action.

Most Projects decided to prohibit master metering in new construction. A fair number of Project jurisdictions had already effected such bans before the Projects began.

The Ohio Project reviewed several courses of administrative action with the major utilities in the state. Most utilities felt a need for commission action on master metering and requested a generic hearing.

The Connecticut Project held such a hearing before establishing a statewide master metering policy, but it was anticipated that the state's independent amendment of the building code would prohibit master metering in new construction.

The Seattle Project worked within the framework of a ban on new master metering. An important legal issue was addressed when an intermediate draft of the ordinance required submetering of converted energy in buildings with central service systems. The decision regarding the legality of submetering was that the utility had the right to charge each tenant for electricity used in central heating systems according to his or her consumption of the converted energy.

In summary most Projects investigated the conservation impact of master metering and found it to be wasteful in most applications. There were major exceptions, however. Under present technology master metering was found to be more efficient in centralized systems and in high rise buildings. Most commissions acted to ban master metering in new construction but exempted specific end uses.

APPENDIX 1

LIST OF ELECTRIC UTILITY DEMONSTRATION AND
PILOT IMPLEMENTATION PROJECT PARTICIPANTS

and

LIST OF PERSONS INTERVIEWED

TABLE 1A

Electric Utility Demonstration and Pilot Implementation 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 (APUC) Ralph Teed (AP&L) Doug S. Windes (DOE)
California	Energy Resources Conservation & Development Comm. (s) Public Utilities Comm. (s) Pacific Gas & Electric (u) San Diego Gas & Electric (u) Southern California Edison (u) Sacramento Municipal Utility District (u)	7/76-P	Richard Hairston (ERCDC) Roger Levy (ERCDC) John Flcry (ERCDC) Jackalyn Pfannenstiel (Smith) (CPUC) formerly of Connecticut PUCA Doug S. Windes (DOE)
Connecticut	Public Utilities Control Auth. (s) Connecticut Light & Power (u)	6/75-3/77	Jackalyn Pfannenstiel (Smith) (PUCA)
Edmond, Oklahoma	City of Edmond (s) Edmond Municipal Electric Co. (u)	12/76-6/78	Paul Buntz (EO) Doug S. Windes (DOE)
Los Angeles, California	Department of Water & Power (u)	6/75-9/79	Dennis Whitney (LADWP) Doug S. Windes (DOE)
Michigan	Public Service Commission (s) Detroit Edison (u)	8/75-12/77	Robert Benko PSC Jane Christophersen (DOE)

(continues)

TABLE 1A (continued)

Location	Participants	Performance Period	Key Project Personnel
New Jersey	State Energy Office (s) Jersey Central Power & Light (u)	6/75-5/80	Charles Rickman (SEO) Paul Johnson (DOE)
New York	Public Service Commission (s) Consolidated Edison (u)	1/76-6/77	Joseph Rizzuto (PSC) Doug S. Windes (DOE)
North Carolina	Utilities Commission (s) Carolina Power & Light (u) Blue Ridge Electric Membership Corporation (u)	7/76-8/79	Antoinette Wike (NCUC) Jane Christophersen (DOE)
Ohio	Public Utilities Commission (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 (s) Water Resources Authority (u)	7/76-7/80	Alberto Bruno-Vega (C) Paul Johnson (DOE)
Rhode Island	Public Utilities Commission (s) Blackstone Valley Electric Co. (u)	7/76-10/78	Thomas Chmura (PUC) Lewis Bailey (BVEC) Christina VanSickle (DOE)
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)

(continued)

TABLE 1A (continued)

Project Location	Participants	Performance Period	Key Project Personnel
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 Commission (s) Wisconsin Public Service Corp. (u)	9/75-11/80	James Simpson (PSC) Richard E. James (WPSC) Jane Christophersen (DOE)

PILOT IMPLEMENTATION PROJECTS

California	Energy Resources Conservation and Development Commission (s)	10/77-12/82	Richard Hairston (ERCDC) Doug S. Windes (DOE)
Connecticut	Public Utilities Control (s)	10/77-9/82	C. T. Caprina (PUCA)
Grand River Dam Authority	Grand River Dam Authority (u)	10/77-9/79	Jerry Taylor (GRDA) Jane Christophersen (DOE)
Iowa	Iowa State Commerce Commission (s)	10/77-9/80	Robert J. Latham (ISCC) Jane Christophersen (DOE)
Minnesota	Department of Public Service (s)	10/77-9/82	Larry Anderson (DPS) Paul Johnson (DOE)
Springfield, Missouri	City Utilities of Springfield (u)	10/77-1/80	John L. McMahan (CU) Jane Christophersen (DOE)

(continued)

TABLE 1A (continued)

Project Location	Participants	Performance Period	Key Project Personnel
North Carolina	North Carolina Utilities Comm. (s)	10/77-10/82	Andrew W. Williams (NCUC) Jane Christophersen (DOE)
Ohio	Public Utilities Commission (s)	10/77-3/81	John Borrows (PUCO) Jane Christophersen (DOE)
South Dakota	South Dakota Public Utilities Commission	10/77-3/78 ^d	Joe Norton (SDPUC)
Seattle, Washington	Seattle City Light (u)	10/77-9/82	Robin Calhoun (SCL) Nancy Tate (DOE)

Source: Compiled from Electric Utility Demonstration and Pilot Implementation 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.

^dProject terminated.

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

Robert Latham	Iowa State Commerce Commission Des Moines, Iowa
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