ISSUES AND RESULTS FROM THE EVALUATION OF THE ADOPTION AND ENFORCEMENT OF MODEL CONSERVATION STANDARDS

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ABSTRACT

We implemented a multi-faceted evaluation of the adoption and enforcement of building codes and utility hook-up requirements in jurisdictions that adopted the Northwest Power Council's Model Conservation Standards. Evaluations of building energy codes present several problems that are not encountered in the evaluations of retrofit programs. In addition to a process evaluation of implementation of the codes, we had to deal with the differences between enforcement, compliance, and energy impacts. This paper describes the evaluation of the implementation of building codes. It covers training, costs, procedures, and problems. Special research efforts were necessary to deal with evaluating compliance. Detailed inspections, blower door tests, and infrared video thermography tests were used. The effect of noncompliance on energy use was estimated based on "as built" conditions. Finally, the design of the impact evaluation based on billing records will be discussed.

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INTRODUCTION

In its 1983 Power Plan, the Northwest Power Planning Council (Council) formulated a set of energy efficiency standards for new residential and commercial construction. These standards, called the Model Conservation Standards (MCS), were required under the provisions of the Pacific Northwest Electric Power Planning and Conservation Act (P.L. 96-501) that established the Council. The goal of the MCS was to ensure that all new construction in the region served by the Bonneville Power Administration (Bonneville) would be built to a standard of energy efficiency that was economically feasible and regionally cost-effective.[1] This would avoid the need to weatherize the buildings at a later date, and it would reduce the size of the energy load that new construction would put on the power system. The Power Planning Act put teeth behind the standards by authorizing Bonneville to surcharge, between 10 and 50 percent, the price of power sold to utilities in jurisdictions that do not adopt and enforce such model standards, or propose an acceptable alternative plan to obtain an equivalent level of electrical energy savings.

The two most apparent ways to get energy efficient building practices "enforced" would be either through building codes or utility hook-up requirements. To encourage adoption and help support enforcement of MCS before the 1986 deadline originally set by the Council (later amended to 1989), Bonneville set up an early adopter program, which sought voluntary early adoption in exchange for incentives for builders and financial support for enforcement. The first major early adopter was the City of Tacoma, Washington. It began enforcing the MCS as an electrical building code within the city on June 1, 1984. On October 1, 1984, Tacoma City Light, the municipal utility, began enforcing the standard as hook-up requirements for new electrically heated homes in its service territory outside of the city limits. Since that time, at least five smaller Washington jurisdictions have adopted the MCS.

Role of Evaluation

A main emphasis within the region has been on the costs and benefits of the model conservation standards. Policymakers recognized the value of evaluating the early adoption programs, both to document the results for others considering adoption, and to establish a reliable basis for determining the costs and benefits of a policy that could force the adoption of the MCS through a surcharge. A large demonstration program (Residential Standards Demonstration Program) was collecting data on the cost of installing the types of measures required by the MCS. These costs were only part of the costs of MCS. If the MCS were to be implemented there would be start-up, training, codification, and enforcement costs. In addition, the demonstration program used innovative volunteer builders, many of whom had some experience with building energy efficient homes. Code enforcement would require all builders of electrically heated homes to meet the MCS, not just volunteers. Enforcement costs could be expensive; compliance may be grudging and involve short-cuts. While a competitive market might lower measure costs, the less than voluntary compliance could result in lower savings.

The evaluators were initially given what appeared to be straightforward tasks: "Find out how much these codes cost and how much energy is saved by regulations." In practice, the issues were quite complex; the data had never been collected before, and there was little previous evaluation experience to draw upon. The evaluation of the early adopter program eventually involved a process evaluation, an impact evaluation, and several related research efforts.

The purpose of this paper is to describe the evaluation issues that were encountered and how they were handled. The complete results of the research described in this paper are available for interested readers.[2] The next section will describe the issues involved and the research undertaken; and the final section will discuss our conclusions about the evaluation process.

EVALUATION ISSUES

The formal evaluation literature has not dealt with code enforcement as an energy saving strategy. In a related work, Shaffer (1985) examined the impact of Seattle's adoption of energy efficiency standards for buildings that converted to electric heat. Among the problems encountered there were building owner hostility, minimal primary data, and the difficulty of establishing a control group when everyone in a similar situation is covered by a code "program." The all-inclusiveness of a code avoids self-selection issues; however, care must be taken to obtain a good control group.

The key assumption made in our evaluation was that baseline costs, building practices, and energy efficiency found in pre-code homes would have continued in the absence of the code. This assumption allowed us to look at current practice code enforcement costs, energy code compliance rates, and the energy consumption patterns of recently constructed homes as a baseline or control for the code impacts.

Costs

The costs of the MCS enforcement as a code were seen as (1) the incremental cost above enforcement of current energy codes in buildings, (2) the cost to the political entity of adopting the MCS as a code, and (3) the complete cost of the required measures. The last component could be obtained from the very detailed, component by component costs reported by the builders of the 400 demonstration homes (Vine, 1986). This is being supplemented by a survey of material and labor costs in early adopting communities, and personal interviews with builders who have constructed several MCS homes (City of Tacoma, 1986). The cost of adoption to jurisdictions is fairly minimal as reported by each early adopting community. However, the incremental costs of enforcement were hard to obtain.

The measurement of an increment, or change, requires valid measures of both baseline and new costs. The enforcement baseline was elusive. First, not all areas were enforcing energy codes prior to MCS, even though the affected areas had state codes in effect. Second, the building departments were not able to separate energy code enforcement costs from health, safety, and structural code costs. Inspection visits and plan reviews looked at several areas at one time.

In order to get an approximation of the possible incremental enforcement costs, Bonneville sponsored a simulation exercise in each of the four states. Building code officials either tracked (or estimated) their labor and travel costs for current practice homes and nonresidential buildings. They then estimated the extra time and effort involved if they had to enforce the MCS. The results were an analyst's nightmare (McCutcheon et al., 1985a). Within 31 simulations the range of incremental enforcement costs was $11 to $648--even after standardizing the overhead rates at 110 percent of salary rather than using the overhead costs reported, which ranged from $1.97 to $129. Nevertheless, the median cost was $97 per building, and Bonneville offered a reimbursement of $125 per building to most early adopters.

The City of Tacoma received a different enforcement reimbursement, because it proposed using a special five-person team to handle all MCS training, plan review, incentive payment,[3] and enforcement for the Buildings Department and the Tacoma City Light utility hook-up standards. We mention this because this made it difficult for the evaluation team to determine how much these functions would have cost had they been integrated into other departmental enforcement efforts. Although the budget for the special energy team was a clear incremental cost, it wouldn't be representative of general enforcement experience with MCS. In the first Tacoma process evaluation, this issue was approached by disaggregating the time and costs of plan reviews and inspections to determine the incremental cost per MCS home. If the MCS enforcement function were fully integrated, the cost of enforcement could be as low as $61 per home, versus the $135 incurred by Tacoma (Lerman and Bronfman, 1985).

A final effort was made in late 1985 to use the experience of other early adopters besides Tacoma to estimate the incremental enforcement costs. In that research 14 MCS enforcement case studies from three jurisdictions were followed and costs tracked. This includes using telephone time logs, field visit time, office time, and average hourly wages for jurisdictions where the code specialist was partially integrated. Summing the discrete activities resulted in incremental cost estimates of $120 per home (McCutcheon et al., 1985).

Neither the cost simulations, the Tacoma process evaluation, nor the data collected from other early adopters were definitive by themselves. However, the evaluation efforts provided enough information from enough methods for Bonneville to propose a regionwide reimbursement schedule for enforcement costs. Given the results ($97, $61-135, and $120) Bonneville was comfortable offering all but the smallest jurisdictions $125 per home in enforcement assistance.

Energy Issues

The goal of the MCS was to reduce the energy consumption in new electrically heated buildings, and the Power Council was seeking a code-type mandatory program to achieve this goal. The evaluators of the early adopting jurisdictions were prepared to look at KWh savings from actual billing records. However, there is no direct link between adopting a code and saving energy. The code depends on enforcement, which may or may not result in compliance, which, in turn, may or may not result in energy savings. The evaluators soon realized that what was being evaluated is elusive. Was the early adopter program a success if a jurisdiction adopted the MCS? Or if it actively enforced the code? Or if the builders complied with the code? Or was it a success only if it saved the amount of energy estimated by the Council?

Adoption was easy to measure: either a legally empowered body passed the required ordinances or it didn't. Assessing enforcement was more problematic. Site visits could entail "drive-bys" or rigorous inspections. The evaluators originally intended to compare compliance rates by the type enforcement used. However, this was thwarted because all of the early adopter jurisdictions basically used plan reviews and site visits. Most parties quickly concluded that the best way to enforce an energy code was a combination of plan reviews and site visits--just like experienced code officials have enforced health and structural codes.

Compliance was the most difficult measurement aspect of the train of evidence from code adoption to energy savings. The problem centered on whether compliance should be assessed in terms of the specific MCS code requirements, or whether compliance should be assessed against the intent of MCS, which is to reduce electricity use in new buildings. If the theoretical bases for the MCS were correct, full compliance should result in dependable savings. However, in the political arena surrounding the MCS, compliance, rather than energy savings, was seen by builders and local officials as their only responsibility. After all, they have no control on how the occupants will use energy, whether the occupants will puncture air barriers, or even whether a home in full compliance would perform as the Council predicted. For a variety of reasons, the evaluators chose estimated energy savings as the measure of compliance. This decision was the result of considerable thinking on three issues.

- What about a house that fails on only one MCS item; does the whole house fail?

° Should each MCS item be given equal weight so that failures on small items are the same as failures on large items?

° Can overcompliance on specific items compensate for noncompliance on other items?

If compliance were evaluated strictly on an item-by-item basis, and judged strictly, houses reflecting these three situations would be much more likely to fail than if the house were evaluated as a whole.. The only way to evaluate all MCS items, with proportionate weighting, was to use a common measuring stick, which is estimated energy consumption. The research problem still remained as to how to gather the data to measure energy consumption and savings.

The evaluators knew very little about what to expect or how to measure compliance. Prior national work depended on building code officials' (Feinbaum, 1981) or builders' self reports (McCold, 1984). One study was done by the Oregon Buildings Division (PMA, 1980) that examined builder compliance with the Oregon energy code by physically inspecting buildings that had passed local code inspections. Bonneville paid for a follow-up study (PMA, 1985) that sampled 159 homes in eight jurisdictions to determine if compliance improved with the passage of time. While compliance had improved in some components of the home, seven years after the code adoption, full compliance was far off.

The 1985 PMA report noted that physical re-inspection of completed buildings could not measure all components--e.g., insulation over window headers or subfloor sealants. The MCS depended even more on measures that would be covered up in a finished home, e.g., continuous vapor barriers, mud sill, and door jamb caulking. Since the ratepayers in a jurisdiction could be surcharged if the jurisdiction failed to obtain compliance, the evaluators were given the difficult task of finding a way to reliably measure compliance over a four state region--probably on a sample basis.

The most obvious and reliable method would be to inspect building sites during construction, immediately after the local jurisdiction's inspector finishes and before the builder continues building. However, the logistics of the timing and travel, as well as the need to coordinate with the code officials whose work is being verified, presented insurmountable barriers. Another less obtrusive measure was needed.

In addition to the careful re-inspections used in the PMA-Oregon studies, two technologies had recently been used on the Hood River Conservation Project: infrared thermography to locate insulation voids in walls, and blower door tests to find the location and size of air leakage in homes. Under contract to Bonneville, a consulting firm undertook research in support of the evaluation of compliance (McCutcheon, et al., 1985b).

The approach used physical inspections in conjunction with thermography and blower door tests on the same MCS houses (N=58). The primary purpose of the research was to identify a field testing method that could determine compliance with MCS. It was desired that the method be easy to use, inexpensive, and above all reliable. The physical inspections included going to the furthest points in the attic and crawls space, checking the depth of insulation and the quality of workmanship. The infrared thermography was actually a video tape that could show the flow of drafts out of light fixtures and door sill plates. The blower door was used to pressurize the home for the thermography as well as to test for air tightness.

Given that we could collect data in three ways; i.e., inspection, thermography, and blower door tests, we still needed to define "compliance." As seen above, full compliance on literally a hundred items was difficult to achieve even after many years of builder experience (PMA, 1985). Should a house be considered out of compliance when one component does not meet the standard? Should every noncomplying item be given equal weight? And how can the energy effect of noncompliance be measured? The solution arrived at by McCutcheon et al. (1985b) was to use the Council's compliance expectation of 85 percent as the measure of pass/fail. They then ran a thermal model, WATT-SUN, for each home as if it were built to strict MCS, followed by another run of the model for the house "as found" based on inputs from all three tests (inspections, thermography, and blower door). If the "as found" result was at least 85 percent of the efficiency of MCS, it was considered in compliance. (Only 36 homes actually got the thermography test due to its expense). For the 36 MCS homes in early adopting communities in Western Washington State, the lack of total compliance only resulted in the homes using an extra 9 percent of energy, according to the thermal simulations model--the common measuring stick. If the thermography test results were dropped, the average energy penalty for the total 58 homes was not significantly different from zero.

When the individual measures (inspection, thermography and blower doors) were used to <u>predict</u> whether a house passed or failed, as measured against the WATT-SUN model estimate using all three inputs, the results were very unsatisfying. Despite the endogenous correlation caused by using a variable which is also part of the index of compliance, no single test did much better than chance at predicting pass/fail.[4] Although the contractor recommended using spot reinspection in conjunction with a blower door, BPA has continued the search for a single, simple, and inexpensive method of monitoring compliance.

Energy Savings

Although compliance is a central issue in the region in terms of surcharge policy, the cost-benefit analysis of the MCS must depend on the measure of energy savings. One regional measure of potential energy savings will come from the Residential Standards Demonstration Program (RSDP) in which 400 current practice and 400 MCS homes were separately metered for space heating use. However, the RSDP/MCS homes were built by voluntary builders and usually far exceeded the MCS requirements for thermal efficiency. Likewise, the current practice homes that make up the comparison group volunteered for the experiment and often gave up burning wood for heat. The evaluation team felt that the savings results from the RSDP research must be tempered with savings estimates from actual code enforcement pilots. The early adoption of the MCS by the City of Tacoma and Tacoma City Light provided a large enough pilot situation to obtain meaningful results.

The problem of finding an appropriate control group to represent what would have happened to energy consumption in the absence of the MCS was approached by looking at a sample of electrically heated homes built in the 2 years preceding the adopting of MCS. By following their electricity

consumption through the same heating season as the first year of MCS home experience, a measure of the incremental efficiency of MCS can be obtained. Over 400 current practice (pre-MCS) homes were identified from assessor's files and about 200 MCS homes were available for analysis in the winter of 1985-86. The Princeton Scorekeeping Method (PRISM) will be used to normalize to 30-year average weather conditions and billing periods of unequal length. In addition, by examining the consumption patterns of both samples of homes and local weather, those homes using a substantial portion of nonelectric heat (e.g., wood) will be identified and eliminated from the analysis. In that way the energy savings that result from enforcement of an MCS code can be approximated for real homes, under actual occupancy conditions, and using unobtrusive measures. (Lerman et al., 1986). [The analysis is expected to be completed in September 1986.]

CONCLUSION AND SUMMARY

The evaluation of the impact of energy codes is a new area of research. Our experience was that many concepts and goals have not been clearly defined. Much of the research described in this paper was directed at finding proper methodologies, redefining issues, and understanding the context of code enforcement, rather than toward measuring the cost and savings. The description of the issues and methods to deal with them was the purpose of this paper; it is also a measure of the developments in the area of code evaluation.

Substantively we found that code adoption may not be equated with energy savings; that the best way to enforce an energy code is by plan review and site inspections--just like any other building code; and that, although 100 percent compliance is not possible, good compliance should achieve most of the available energy savings. We haven't found an ideal way to monitor MCS compliance on a regionwide basis, but the Power Planning Council has pushed back the threat of a full surcharge to 1989. The evaluation effort will have sufficient time to prepare and test a methodology by then. In the meantime, we feel that significant progress has been made in resolving the most difficult issues.

ENDNOTES

[1]The Power Act permitted the Council to clarify the definition of economic feasibility (based on the owning and operating life-cycle costs over the life of the mortgage.) Regional cost effectiveness was defined as a measure, or resource, that is reliable and available at the time needed, and at an estimated incremental system cost no greater than a similarly available resource. The Council's preliminary analysis was supported in the 9th District Court on April 10, 1986.

[2]Address requests for related reports to the first author at Bonneville/KES, P.O. Box 3621, Portland, OR 97208.

[3]To soften the impact of Tacoma's early adoption, an incentive of up to $4800 per home was provided to complying builders who also put in an air-to-air heat exchanger.

[4]This overview simplifies the analysis in the report. Interested readers should request the complete report (McCutcheon, et al., 1985b)

REFERENCES

City of Tacoma (1986, forthcoming) "Model Conservation Standards' Survey of Builder Costs". Office of Intergovernmental Affairs, City of Tacoma, WA.

Feinbaum, Robert (1981) "The California Experience with Energy Conservation Standards for Buildings". University of California, Lawrence Berkeley Laboratory, Berkeley, CA.

Lerman, D., and Bronfman, B. (1985) "Process Evaluation of the Tacoma MCS Adoption: Part I". Evaluation Research Corporation, Portland, OR (ERC/PO-8).

Lerman, D., Horowitz, M., and Bronfman, B. (1986, forthcoming). "Process and Energy Impact Evaluation of the Tacoma MCS Adoption: Part II". International Energy Associates (formerly ERC), Portland, OR.

McCold, Lance N. (1984) "Thermal Efficiency Standards and Codes: Volume 2, Relationships of ASHRAE Standards and External Factors to Energy Efficient Building Practices in New Homes". Oak Ridge National Laboratory, Oak Ridge, TN.

McCutcheon, L., Cullen, G., McDonald, C., and Weinstein, M. (1985a) "Evaluation Design for MCS Code Adoption Demonstration". Synergic Resources Corporation, Seattle, WA (SRC #7239).

McCutcheon, L., Cullen G., Scott, S., Snow, C., McDonald, C, and Hussey, D. (1985b) "Evaluation Results for MCS Code Adoption Demonstration Project". Synergic Resources Corporation, Seattle, WA (SRC #7239-R2).

Performance Management Associates (1980) "Compliance Review, Chapter 53." PMA, Portland, OR 97201.

Performance Management Associates (1985) "Oregon Building Code Compliance Study." PMA, Portland, OR 97201.

Shaffer, Jean C. (1985) "Evaluating Energy Conservation Regulations". Proceedings of the Second National Conference on Conservation Program Evaluation. Argonne National Laboratory, Chicago, IL, Vol. I, pp 6-14.

Vine, Edward (1986). "The Residential Standards Demonstration Program Cost Analysis." University of California, Lawrence Berkeley Laboratory, Berkeley, CA.