How Well Is Our Energy Code Working? An Evaluation of the Tacoma, Washington Model Conservation Program

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Since 1984, new and remodeled buildings which use electric space heat and are served by Tacoma City Light have been required to comply with the Model Conservation Standards (MCS), an energy performance standard. MCS is based on ASHRAE 90A specifications for building components but sets higher standards for performance.

In 1992 Tacoma Public Utilities and a consulting firm conducted a program evaluation of the MCS program, focussing on (1) compliance levels, (2) energy use impacts, (3) program strengths and weaknesses, and (4) possible program improvements.

The evaluation was based on field audits, interviews with builders and code officials, and administrative records. Compliance calculations were based on the percentage of the building measures required by MCS which were in place and functioning. Study findings have been used to guide local and state energy code programs.

The study found compliance levels of 88% for commercial buildings and 91% for residential buildings. Overall building energy efficiency is high. Non-compliance was greatest for water conservation and domestic hot water pipe insulation, areas with low energy use.

Program strengths include competency of code officials, and general public support. Program weaknesses include inconsistency in code interpretation across jurisdictions, lack of commercial rebates, and code complexity.

Improvements suggested by participants include training for builders, continuing residential rebates, consistent enforcement, adding commercial rebates, and code simplification.

This paper will present (1) the approach used to evaluate code compliance, (2) study results, (3) applications of results, and (4) applicability of results to other code enforcement programs.

Introduction

Since 1984, new and remodeled buildings which use electric space heat and are served by Tacoma City Light have been required to comply with the Model Conservation Standards (MCS), an energy performance standard. MCS is based on American Society of Heating, Refrigerating, and Air-Conditinion Engineers, Standard 90A-1980 specifications for building components but sets higher standards for performance.

Tacoma's City Light's implementation of the Model Conservation Standards (MCS) has been ambitious. Adopted in June 1984, Tacoma led the Northwest as the first adopter of a more stringent energy code. The MCS program involves three contiguous jurisdictions which are all served by Tacoma City Light: the city of Tacoma, the city of Fife, and Tacoma City Light's service territory in Pierce County outside of Tacoma and Fife.

Research Approach

The research approach responded to the goals of this evaluation, which were to assess various aspects of Tacoma's implementation of the MCS—from the beginning of 1990 to the end of 199 l—for new electrically heated residential and commercial construction, and for

space heating conversions and remodels. These aspects included the:

- Level of code compliance by sector and by jurisdiction
- Factors influencing code compliance
- Effects of MCS on energy consumption ‘
- Effectiveness of program administration
- Costs of building and administering the MCS
- Benefits and strengths of the program
- Needed improvements to the program

The evaluation was based on field audits, interviews with builders and code officials, and administrative records. Compliance calculations were based on the percentage of the building measures required by MCS which were in place and functioning.

Field Audits of MCS Buildings

Sample. A stratified random sample was designed and implemented for this study. The sample was drawn from a population of 1,044 MCS permits which had final inspection dates between January 1, 1991 and December 31, 1991. This period defines the “modern” era for the MCS program, the most recent period of stable program operation prior to an MCS compliant version of the Washington State building code being passed.

Study Domains. The objective was to represent the level of MCS compliance within two study domains: (1) Commercial buildings and (2) Residential buildings. The project budget allowed for a relatively small sample. To increase the efficiency, and thus decrease the relative error of this sample, we developed and implemented a stratified random selection procedure. The sample was divided equally between the two domains of study. Each of these domains were stratified by building use and permitting agency. Within each domain of study the sample was allocated to each stratum (defined by building use and permitting agency) in proportion to the share of permits present in each stratum. Random replacements were made within each stratum whenever a building owner refused to participate in the study. The minimum total sample was set to 50, although provisions were made for increasing the total if budget allowed.

Weighting. To examine the level of compliance for the entire population, the data were weighted. These weights were calculated by dividing the total number of permits in each stratum by the number of audited permits in each stratum. These weights were assigned to each case in the database and were used to estimate compliance for the entire population.

The sample selection process resulted in the sample of completed site audits as shown in Table 1. The results shown in this chapter have been weighted to reflect the total sample frame of 1,044 building permits.

Table 1. Audited Permits by Sample Strata

Building Use	Agency	Permits N	Permits %
Commercial	Fife	6	10.7
	Tacoma	17	30.4
	TPU	7	12.5
	Domain Total	30	53.6
Multifamily	Tacoma	2	3.6
	TPU	1	1.8
Single Family	Tacoma	7	12.5
	TPU	16	28.6
	Domain Total	26	46.4
		56	100

Builder and Code Official Interviews

Builder Interviews - Interviews were conducted with 26 builders participating in the MCS program. The purpose of these interviews was to determine builder satisfaction with the MCS program, to explore problem areas and solutions to those problems, and to collect information on builder background experience.

There were a total of 49 builders for the 56 sites visited. 33 builders were able to be contacted and interviews were conducted with 26 (79%) of them. Scheduling difficulties were the main reason for the failure to complete more interviews.

Code Official Interviews - Interviews were conducted with 11 people involved in various aspects of the MCS enforcement process. Those interviewed included six people who enforce the code in City Light’s service

territory outside of Fife and Tacoma; three people who enforce the code in Tacoma; and two people who enforce the code in Fife.

Given the small number of respondents, and the wide variety of roles they fill, this analysis was necessarily qualitative.

Research Procedures

Field Audits

For the field audits, the level of MCS compliance for each feature was coded as (1) Full Compliance, (2) Partial Compliance, (3) Non-Compliance, (4) Insufficient Information; or (5) Feature Not Applicable.

Two of these terms deserve further explanation. *Partial compliance* with the code was coded when observations 'were made of both compliance and non-compliance with the feature at the particular site. Examples include isolated cases of missing duct insulation, weather stripping or caulking; cases where some exhaust ducts had back-draft dampers but other HVAC equipment did not meet efficiency specifications; cases where some domestic hot water (DHW) tanks were insulated properly and some were not; and cases where some faucets and showers met the flow requirements and some did not. Features requiring calculated compliance levels (thermal performance, system sizing, and lighting power budget) are assumed to be either in full compliance or non-compliance after allowing for a 15% tolerance.

Insufficient compliance was coded if we were unable to obtain sufficient information to render a reliable compliance judgement. In these cases the measures could not be readily examined, and permits or construction documents were unavailable or unclear. Please note these cases are not included in the percentage non-compliance calculations because we could not be certain regarding the compliance level to assign.

For each feature, the sources of the compliance information was noted, with the final compliance conclusions based upon the most reliable source. The sources, in order of reliability, are:

1. Direct on-site observation.
2. Plans and permit applications.
3. Information from builders during follow-up interviews.

Please note that we used a strict interpretation of the MCS requirements for the assessment, and that different interpretations are possible in some areas. In particular, the definition of terms such as "workmanship-like" and "using accepted engineering practice" can vary widely among code enforcement officials and construction practitioners.

Limitations to Assessing Compliance. The ability to assess noncompliance rates was limited by three factors:

1. Difficulties interpreting the code;
2. Difficulties observing or otherwise confirming specific construction features; and
3. Changes that may have occurred between the time of the code inspection and our site visits.

In light of these limitations, and constraints on the amount of time that could be invested at any individual site, the mm-compliance determinations must be considered as indications of compliance problem areas, rather than conclusive findings of non-compliance levels.

Rule of Tolerance. For three compliance criteria– System sizing, overall thermal performance, and lighting power budget—we developed and applied a "Rule of Tolerance." Each of these criteria involves a calculation of numerical values to assess compliance and thus could not be coded as partial compliance. In addition, determination of compliance in these areas often involves some professional judgement or slight uncertainties, as described below. Given these factors, we wanted to allow some latitude in our assessment of compliance.

Uncertainty in assumptions used to account for air exchange in efficient buildings can easily cause +/- 10% differences in calculated heat loss and thus in the allowable system sizing. Similarly envelope areas, window and door framing dimensions, and floor areas are subject to measurement errors on the order of 5-10%. With lighting there can be uncertainty about the types of activities conducted in some spaces, and some change in both space use and lamps (particularly replacement of burned out 34 watt tubes with 40 watt units) that may occur over time.

Following a review of the calculated code requirements and as found conditions for each of these three types of compliance criteria, we selected a tolerance level of 15%. Our review revealed distinct clusters in the levels of non-compliance for these criteria. In our opinion, when these three compliance criteria exceed code requirements by 15%, they are clearly out of compliance with MCS requirements. As this "tolerance" is reduced to zero, the non-compliance levels increase significantly, indicating that a large proportion of deviations from the code exist in this narrow band.

Field Audit Findings

Overall MCS Compliance Levels

Based on field audit results, MCS compliance levels are high: 88% for commercial buildings and 91% for residential buildings, with little variation across jurisdictions. Table 2 displays the overall non-compliance levels for commercial and residential buildings, and for the three jurisdictions which enforce the MCS—the cities of Tacoma and Fife and TPU. In this table, 'N' represents the number of permit sites actually audited in the sample. The percentage reflects the population proportion, based upon a weighting of each sampled permit.

Table 2. Levels of MCS Non-Compliance

	Overall		TPU		Tacoma		Fife	
	N	%	N	%	N	%	N	%
Commercial	30	12	7	6	17	12	6	18
Residential	26	9	17	6	9	13	-	-
N	56		24		26		6	

Table Notes:
N is the number of permit sites actually auditied in the sample.
% reflects the population proportion, based upon weighting of each sampled permit.

To calculate non-compliance levels at the sector level, instances of full compliance, partial compliance, and non-compliance for all criteria were totalled by jurisdiction and sector. Percentages were calculated by dividing the number of non-compliance observations by the total number of observations. For example, 20 observations of non-compliance divided by 100 total observations would equal 20% non-compliance.

It is important to note that the sample was selected to represent the two study domains-commercial and residential buildings—and not the jurisdictions. Still, the sample is small and the results should be regarded as general indicators of the level of compliance within each domain. Jurisdictional data should be interpreted even more cautiously, since the sample of buildings from each jurisdiction is even smaller than those used for the sector comparison.

The percentages in Table 2 reflect weights which have been applied to the sample so that population proportions can be estimated. This table shows that we found a low level of non-compliance with the MCS, with no significant variation across commercial or residential buildings or among jurisdictions. The commercial sector non-compliance level was 12% and the residential sector non-compliance level was 9%. Within the commercial sector, Tacoma Public Utilities' level of non-compliance was 6%, with Tacoma at 12% and Fife at 18%. In the residential sector, non-compliance levels were 6% for TPU and 13% for Tacoma.

Non-Compliance by Individual Criteria

The levels of non-compliance by individual compliance criteria are summarized in Table 3 (commercial) and Table 4 (residential). Multifamily sites are included in the residential summary.

The results of audits of the 30 commercial and 26 residential buildings, shown under the "compliance Level" section of these tables, have been weighted to estimate population proportions. The columns labeled "N" reflect this weighting procedure. *Full compliance* was coded when a feature was completely compliant with the code for all relevant observations, or, for a calculated variable, was out of compliance by less than 15%. *Non-compliance* with the code was coded when a feature was clearly out of compliance for all observations of that feature. *Partial compliance* with the code was coded when observations were made of both compliance and non-compliance with the feature at a particular site. *Insufficient information* was coded if we were unable to obtain sufficient information to render a reliable compliance judgment. *Not Applicable* indicates the percentage and number of cases where the particular compliance criteria did not apply to the sites examined.

Non-compliance is low for most individual criteria. The areas of most significant non-compliance appear to be those areas where there is uncertainty surrounding how compliance is determined (e.g. equipment sizing), or where features themselves have relatively minor energy use impacts (e.g. conservation of water; domestic hot water pipe insulation.) Non-compliance with lighting power budgets for commercial buildings is one exception to this statement. Problems here may stem from changes in space use or lighting technology since construction, incorrect determination of building areas or power densities for budget calculation, or lack of enforcement. Some of this non-compliance may stem from a lack of clarity regarding how to do lighting budget calculations at the times these buildings were constructed.

Interview Findings

MCS Builder Perspective

Most builders interviewed were very satisfied with the program and believe it has significantly improved building

Table 3. Summary of Code Compliance for Commercial Buildings

		Compliance Level										Data Source		
		Full		Partial		Non-compliance		Insufficient		Not Applicable		Observation	Plans & Permits	Builder
	Criteria	N	%	N	%	N	%	N	%	N	%	N	N	N
1.	Overall Thermal Performance	276	100	0	0.0	0	0.0	0	0.0	0	0.0	13	8	0
2.	Air Leakage	43	77.2	13	22.8	0	0.0	0	0.0	221	80.1	7	0	0
3.	System Sizing	235	85.2	0	0.0	41	14.8	0	0.0	0	0.0	10	2	0
4.	Exhaust Systems	30	54.1	17	30.1	0	0.0	9	15.8	220	79.8	7	1	0
5.	Simultaneous Heat and Cool	62	85.5	0	0.0	11	14.5	0	0.0	203	73.7	8	0	1
6.	HVAC Equipment Performance	30	82.8	6	17.2	0	0.0	0	0.0	240	86.8	4	1	1
7.	Energy for Air Delivery	6	50.0	0	0.0	0	0.0	6	50.0	263	95.4	0	0	0
8.	Balancing	0	0.0	0	0.0	0	0.0	0	0.0	276	100	0	0	0
9.	Cooling with Outdoor Air	0	0.0	0	0.0	0	0.0	0	0.0	276	100	0	0	0
10.	Controls	73	82.8	15	17.2	0	0.0	0	0.0	188	68.2	11	0	0
11.	Duct Insulation	58	100	0	0.0	0	0.0	0	0.0	218	79.0	8	0	0
12.	Piping Insulation for HVAC	28	100	0	0.0	0	0.0	0	0.0	248	90.0	4	0	0
13.	Water Heating	45	87.6	6	12.4	0	0.0	0	0.0	225	81.6	7	0	0
14.	Pump Operation	0	0.0	6	100.0	0	0.0	0	0.0	270	97.7	1	0	0
15.	Pipe Insulation for DHW	31	61.9	0	0.0	19	38.1	0	0.0	225	81.6	7	0	0
16.	Conservation of Water	13	58.7	0	0.0	9	41.3	0	0.0	255	92.2	3	0	0
17.	Lighting Switching	203	81.8	17	6.8	19	7.8	9	3.6	28	10.2	27	0	0
18.	Lighting Power Budget	193	70.0	0	0.0	83	30.0	0	0.0	0		28	8	0
Total Features		1326		80		182								
Overall Compliance		83.5%		5.1%		11.5%								

energy efficiency. The reasons for favorable ratings included the:

- Expertise of the inspectors and plan checkers
- Level of rebates available from the residential Super Good Cents program
- Willingness of the code officials to work with the contractors, and
- Fine-tuning of the program after relatively rocky beginnings.

The reasons for unfavorable ratings included the:

- Inefficiency of regulations
- Requirements for air exchangers and double vapor barriers.

Program Importance. 58% of the builders believed that the MCS program has been important in improving the energy efficiency of buildings in the area, while another 35% stated it is somewhat important. The most common reason given for this belief in the effectiveness of the MCS was that without uniform codes builders of

Table 4. Summary of Code Compliance for Residential Buildings

	Compliance Level										Data Source	
	Full		Partial		Non-Compliance		Insufficient		Not Applicable		Observation	Plans & Permits
Criteria	N	%	N	%	N	%	N	%	N	%	N	%
1. Overall Thermal Performance	738	96.1	0	0.0	30	3.9	0	0.0	0	0.0	26	2
2. Air Leakage	493	64.2	246	32.0	29	3.8	0	0.0	0	0.0	26	3
3. System Sizing	533	69.4	0	0.0	235	30.6	0	0.0	0	0.0	26	7
4. Exhaust Systems	680	88.5	29	3.8	30	3.9	29	3.8	0	0.0	26	1
5. Simultaneous Heat and Cool	0	0.0	0	0.0	0	0.0	0	0.0	768	100.0	0	0
6. HVAC Equipment Performance	537	95.5	25	4.5	0	0.0	0	0.0	206	26.9	19	0
7. Energy for Air Delivery	0	0.0	0	0.0	0	0.0	0	0.0	768	100.0	0	0
8. Balancing	0	0.0	0	0.0	0	0.0	0	0.0	768	100.0	0	0
9. Cooling for Outdoor Air	0	0.0	0	0.0	0	0.0	0	0.0	768	100.0	0	0
10. Controls	768	100.0	0	0.0	0	0.0	0	0.0	0	0.0	26	0
11. Duct Insulation	560	85.6	29	4.5	0	0.0	65	9.9	114	14.8	20	0
12. Piping Insulation for HVAC	88	100.0	0	0.0	0	0.0	0	0.0	680	88.5	3	0
13. Water Heating	620	87.6	59	8.3	0	0.0	29	4.1	60	7.8	24	0
14. Pump Operation	0	0.0	0	0.0	0	0.0	0	0.0	768	100.0	0	0
15. Pipe Insulation for DHW	569	80.3	0	0.0	140	19.7	0	0.0	60	7.8	24	0
16. Conservation of Water	448	58.3	89	11.5	232	30.2	0	0.0	0	0.0	26	0
17. Lighting Switching	0	0.0	0	0.0	0	0.0	0	0.0	768	100.0	0	0
18. Lighting Power Budget	768	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0
Total Features	6802		477		696							
Overall Compliance	85.3%	6.0%	6.0%		8.7%							

efficient homes would not be able to compete in the marketplace where first cost is the dominant concern.

Availability of rebates under the Super Good Cents residential program was another commonly stated reason. Super Good Cents is an optional program which offers incentives to builders and buyers of new single family residential buildings and manufactured homes which exceed current energy code standards. Incentives include training and technical support, promotion, certification, and design and lending assistance.

Ratings of MCS Semites. Builders rated various components of the MCS program from excellent to poor. The items regarded most favorably were "help from code enforcement officials", and "the quality of inspections." The least favorable ratings were given to "help with marketing", and "consistency across jurisdictions." Differences in consistency included levels of inspector expertise and their willingness to make exceptions, and interpretations of code requirements with respect to sealing and equipment sizing.

Building Beyond MCS. Most of the builders responding don't build more efficiently than the MCS (62%), while 19% said they usually go beyond MCS requirements, and another 19% said they sometimes do.

Costs of MCS. Most builders believe it costs more to build projects that comply with the MCS, but that most of them (84%) also believe they've recouped their losses.

The reasons given for increased costs included:

- Higher cost materials and installation labor, and
- Additional time for inspections and approvals.

The most common methods to recoup losses were through:

- Rebates
- Increased bid/sale prices, and
- Energy savings for owner/builders.

Code Official Perspective

Commercial Code Enforcement. Seven of the ten respondents gave MCS a "somewhat successful" rating in its application to the commercial sector. The other three respondents felt that it has not been too successful. Reasons for this lower level of success, compared to the residential sector, included:

- Less cooperative builders;
- Inconsistent enforcement throughout the state; which causes problems when builders come in from other areas;
- High tenant turnover with tenant improvements and remodels
- No financial incentives
- No support from the electrical inspectors and buildings getting powered without energy code inspection; and
- Builders not knowing that an energy code inspection is required because it was the engineer that got the original permit.

The majority of respondents considered the energy code somewhat important in improving energy efficiency in commercial buildings. They said that the code is not that stringent, but it has reduced lighting budgets and improved insulation levels somewhat. Some expressed concern that there is a tendency to build external shells, which will be completed with tenant improvements at a later date, and that this allows builders to short-circuit the code process.

Residential Code Enforcement. In general, code officials consider the residential aspects of the MCS program as successful. Among the Energy Conservation Office and Tacoma respondents, all but one answered that the program has been very successful in meeting its goals and that the program has been very important in improving the energy efficiency of new and expanding residential buildings.

Some of the reasons given for the success of the residential MCS program included high levels of compliance, close coordination with builders, customer awareness of energy efficiency, uniformity of code across jurisdictions, growing understanding of the code and its requirements, and an increased availability of energy efficient materials and building components.

Possible Program Improvements

Builders. When asked about the single most important thing they would like to relay to Tacoma City Light about the MCS program the MCS builders interviewed offered the following:

- keep up the good work;
- don't reduce the rebate;
- increase the rebate for air-to-air heat exchangers;
- keep the Bonneville Power Administration from having excessive influence over the program
- provide professional training seminars for builders
- simplify the compliance calculation for the performance and systems analysis pathways.

Code Officials. In the area of commercial enforcement, Code officials recommended the following improvements:

- have better communication between the electrical inspectors and the energy code inspectors;
- make sure that all of those in the construction process know they need to pass an energy code inspection;
- simplify the code;
- get energy code inspectors involved earlier in the process, to avoid costly equipment change outs later in the process;
- emphasize the commercial program as strongly as the residential; and increase the stringency of the code.

In the area of residential enforcement, Code officials recommended the following improvements:

- make sure that builders know that they have to comply with an energy code as well as an electrical code;

- work with mortgage lenders to assure that home-owners, and not just builders, see the benefits of the code;

- the ventilation/indoor air quality code could be written more clearly;

- the process for inspecting certain aspects of the code, such as the advanced dry wall approach or vapor barrier paint, needs to be improved.

Discussion

This study, with its broad scope, required efficient use of time and resources. This was achieved by 1) targeting the sample population, 2) weighting the sample data, 3) including audit follow up questions in builder interviews, 4) interviewing code officials with a range of enforcement experience and 5) incorporating existing data into the audit process. Study findings are summarized below:

- Compliance: Based on field audit results, MCS compliance levels are high: 88% for commercial buildings and 91% for residential buildings, with little variation across jurisdictions.

- Factors influencing compliance: Positive factors included competency of code officials, and general public support. Lack of rebates and code complexity impeded compliance in the commercial sector.

- Energy efficiency: Energy efficiency of new buildings is quite high, with the highest levels of non-compliance being in areas with relatively low energy use impact.

- Program Administration: Builders gave the quality of assistance and inspection high marks but rated training and consistency of enforcement less highly. Code officials felt there are needs to improve training and to maintain or increase finding.

- Costs of MCS: Builders and developers felt the MCS has forced up building costs, but that everyone building in the service territory faced the same situation. They also feel that most costs have been reimbursed—through rebates, and energy cost savings to the customer.

- Benefits and Strengths: MCS is achieving its major goals: improved energy efficiency and significant energy savings. Specific benefits noted include improved home construction, measures persistence, increased comfort for occupants, and lower building operation costs.

- Possible improvements: Improvements suggested by study participants include training for builders and subcontractors, continuing residential rebates, ensuring consistent enforcement, adding commercial rebates, ensuring that energy inspections occur before power goes in, code simplification, and interpreting and enforcing the code more effectively.

Study findings were used by the Washington State Building Code Council in revising the non-residential energy code to a simpler code that is easier to implement and enforce. In addition to code simplification, the new code makes provisions for additional code enforcement support, and training and technical services.[2]

Study. findings were also the impetus for reorganization of the utility permit tracking process. The reorganization will enable electrical inspectors and energy code inspectors to enforce codes consistently and efficiently.

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Endnote

1. See Association of Washington Cities et al. (1993).

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