A Comprehensive Approach to Program Information & Evaluation – Nonresidential New Construction

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ABSTRACT

A broad program of statewide Market Assessment and Evaluation (MA&E) activities related to energy efficiency is being undertaken in California. In the Nonresidential New Construction (NRNC) area, these activities seek to answer several questions:

- How does the NRNC market work? Who are the market actors?
- What are the barriers to energy efficiency in this market?
- How much energy are NRNC programs by utilities saving?
- How is the efficiency of new buildings changing over time?
- How are the NRNC market and utility programs operating over time?

The answers to these questions are used by program planners and implementers, regulatory and by stakeholders interested in the of the NRNC market. As a by-product, the data are also used by the energy codes and standards community.

Studies completed to date provide a detailed assessment of baseline energy efficiency practices, both in terms of the efficiency of buildings and the methods used by decision-makers. In addition, a series of on-going studies provide quarterly reports on new construction and remodeling activity in nonresidential sector. They also provide on-going measurement of the efficiency and characteristics of newly built nonresidential buildings (kW, kWh), for comparison to baseline efficiency and to track trends.

The comprehensive approach to MA&E taken by this program has involved multi-year planning of data collection, evaluation, reporting, and coordination with program planners and evaluators. The result is a uniquely rich dataset and series of published reports on the NRNC market.

INTRODUCTION

For at least the past twenty years, the public agencies and utilities in California have sponsored energy efficiency programs, and throughout this time most have included nonresidential new construction (NRNC) programs. Over time, the designs, objectives and effectiveness of these programs have changed in response to the shifting winds of public policy, and the personnel who design and implement these programs have come and gone. While there have been varying degrees of continuity between programs and from year-to-year, there has been little organized or rigorous effort to characterize the NRNC market, to track how it has changed over time, or even to document how the NRNC programs themselves have performed from one year to the next (except in individual year impact or process evaluations). Moreover, there has been little organized effort to use this accumulated experience with the NRNC market to inform program planning efforts.

In 1999, a system of statewide market assessment and evaluation (MA&E) study areas was established, including one for the NRNC program area. One of the objectives of doing MA&E activities on a statewide basis was to establish an on-going program of information gathering and analysis that could transcend the limitations of the earlier regime of year-to-year program cycles, and which could provide an improved basis for future policymaking, program design and implementation.

Two primary sources have been used to develop the information presented in this paper:

1. Qualitative and quantitative surveys of the designers of new buildings– architects and engineers. 68 in-depth interviews were conducted, followed by an additional 160 structured questionnaire surveys. These were supplemented by focus groups and other sources of insight into the NRNC market.
2. On-site audits and DOE-2 simulations of the physical and energy attributes of newly constructed nonresidential buildings. The DOE-2 models are based on the detailed on-site data, and have been calibrated to monthly billing data. In the original Baseline Study (Ref. 1), 667 buildings were surveyed; the dataset has since been expanded to more than 1000 buildings. These comprise a statistically representative sample of the office, retail, school and assembly buildings in the NRNC programs run by the utilities. These four building types represent about 70% of all new floor area in the nonresidential sector. Approximately equal numbers of participant and non-participant buildings are included in the dataset.

The survey research has been used to understand how the NRNC market operates and to assess the strength of market barriers to energy efficiency. The on-site audits and modeling information have been used to understand actual building performance and characteristics. We have combined newly surveyed information with older information from both the surveys and on-site audits from several prior impact evaluation studies of the NRNC programs conducted by the utilities in California.

In developing the studies and reporting activities in the NRNC MA&E program area, we have tried to anticipate the interests of as many potential users for the data as possible, including regulators, policy makers, energy efficiency stakeholders, program designers, administrators, and program implementers. We have attempted to provide a broad spectrum of information about the NRNC market, and about the efficiency characteristics of nonresidential buildings in California. This paper provides a brief introduction to this wealth of information.

NRNC MARKET STRUCTURE AND ACTORS

The foundation of the NRNC MA&E activities is a baseline study of the market – how project teams are structured, how decisions are made, how energy efficiency considerations are brought into the project design, etc. – and of the market actors – the owners, architects, engineers and others who participate in and influence the design and construction processes. It is important that everybody involved in policy development, program design and implementation, and program evaluation have a thorough understanding of the market. We have found from experience that many people have firmly held beliefs about the NRNC market based on an incomplete understanding of how it works. This is a variation of the blind men and the elephant fable, wherein each observer understands only a part of the whole, and so has a skewed perception of the beast. Our studies attempt to describe the whole.

Market Actors

The key actors in the non-residential new construction market are:

- Designers (Architects and Engineers)
- Owners
- Builders (Contractors and Subcontractors)
- Equipment manufacturers

These groups are inter-related in the new construction market in a variety of possible relationships. A useful model of the relationships between market actors is shown in Figure 1. In this structure, the architect is the primary contact with the owner and is the project design leader. The builder (contractor) is the leader of the construction process, and has a direct contractual relationship with the owner. Depending on the structure of the team, these relationships may be strong and direct, as shown here, or may be modified. One common modification is for the architect to be the primary point of contact between the owner and the builder, which gives him/her a stronger role in determining the outcome of the project.

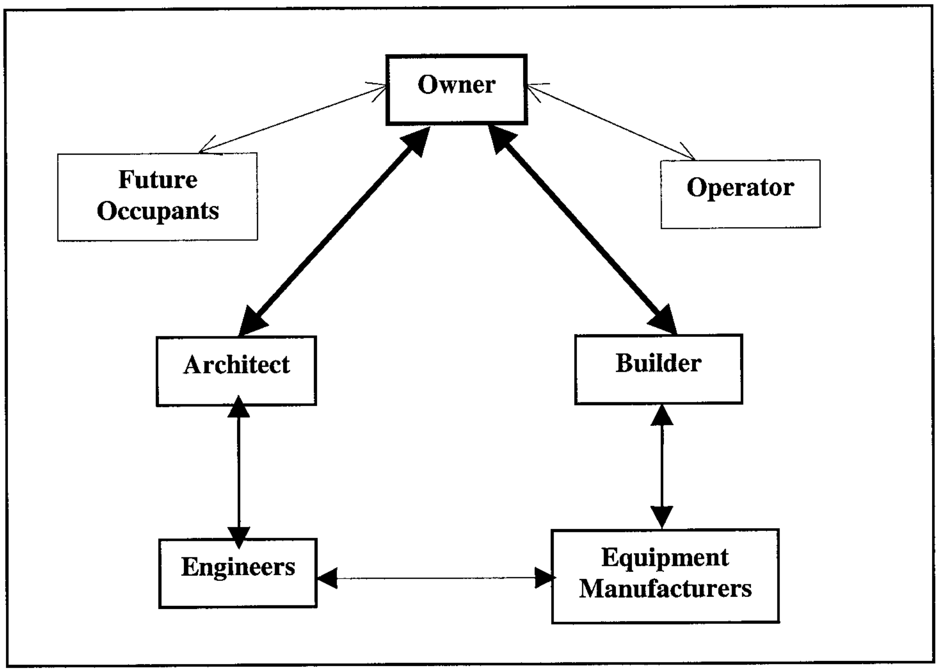

Figure 1: Basic Relationships in New Construction

There are actually several variations of market models based on the type of project, each requiring different market intervention strategies. The applicable market model for a given project is closely linked to the type of building and to the involvement and motivation of the owner.

The major differences in the market models boil down to three points:

1. The relationship between the owner and the ultimate occupant may be weak or strong, affecting the tradeoff between first cost and operation cost (comfort etc),
2. The relationship between the design team and the builder can be weak (competitive bid) or strong (design-build),
3. A construction manager can provide continuity between the design team and the builder.

It is important, for any given project intervention, to understand how these relationships are set up. Likewise, at the program design level, it is important that there be sufficient flexibility in program options to accommodate the variations in project structure. References 1 and 2 develop these models and describe the market actors and teaming arrangements in detail.

Key Market Segments

We found consistent differences in most aspects of energy efficiency among the ownership sectors. But our building data also showed that energy efficient buildings are found in all sectors – public, private owner-occupied and private speculative.

We found that commissioning was most common in the public sector. We also found that the use of optimum energy design was most common in the public sector but was increasing most rapidly in the private owner-occupied sector. In our analysis of the buildings themselves, we confirmed our hypothesis that energy-efficiency was highest in the public sector, followed by the owner-occupied sector. Other key findings include:

- The public sector leads the private sector in virtually all aspects of energy efficiency. In particular, schools are the most efficient of the four building types that we studied in depth.
- However, the private owner-occupied sector does not seem to draw the private speculative sector toward these practices.
- The private owner-occupied sector leads the private speculative sector in virtually all aspects of energy efficiency.
- The public sector seems to draw the private owner-occupied sector toward more innovate design practices such as integrated design methods and building commissioning.

These findings are developed in primarily in References 1 and 2, with additional findings in Reference 4.

MARKET BARRIERS AND INTERVENTIONS

Another important prerequisite to good policies and programs in the NRNC market (or any market for that matter) is a good understanding of the barriers to energy efficiency products and design practices. Some of these barriers are structural – based in the institutional practices and professional attitudes of the market actors – and some are specific to individual technologies or design practices. Once barriers are understood, market intervention strategies and program designs can be developed to overcome the barriers.

Market Barriers

The Baseline Study (Ref. 1) surveyed the primary designers, architects and engineers. Figure 2 shows how they perceived the barriers to energy efficiency in the NRNC market. Split incentives, performance uncertainties and organizational practices were all thought to be strong barriers by both groups of designers.

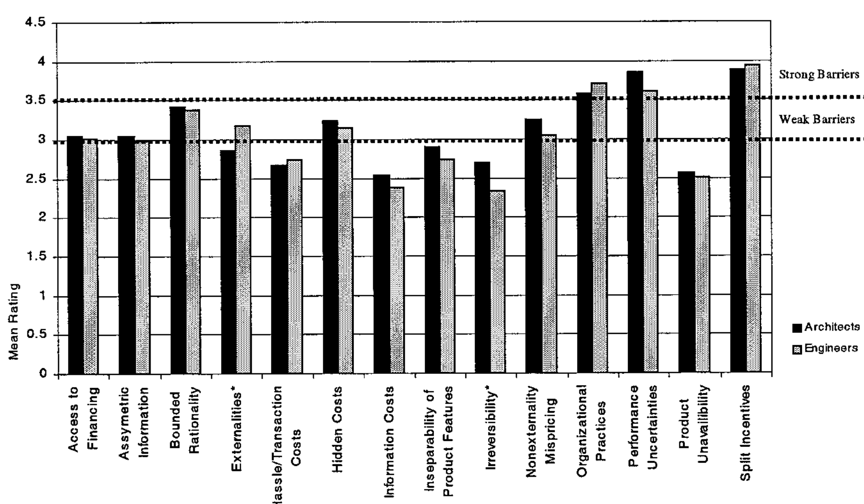

Figure 2: Market Barriers Perceived by Architects and Engineers

Findings about Market Intervention Strategies

To further understand how these market barriers operate in the NRNC market, focus groups were conducted to identify the major needs of market actors which could be addressed through NRNC program designs (Ref. 2). A major finding is that the utility services are of most interest to those that are already committed to and interested in energy efficiency and energy conservation. Not surprisingly, people who lack this interest were least interested in potential program services.

Owners need information and want financial assistance.

1. Committed and educated owners are key to a successful project.
2. Owners and developers are primarily concerned with project schedule and budget, and do not want "assistance" to negatively impact either.
3. Owners are interested in financing options that address long payback issues.
4. Owners are interested in programs that address better comfort control and improved flexibility for the occupants.
5. Owners still see incentives as perhaps the most effective program offering.

Architects need design assistance and support from their clients.

1. Architects often cannot afford to explore energy efficient alternatives due to project time and budget constraints.
2. Architects experience constant design fee pressures because there are other firms willing to provide design services at a lower fee.
3. Architects need their clients to be educated on the benefits of energy efficiency design and for their clients to ask for additional energy efficiency services.

Engineers want a more integrated design role and need technical support.

1. Engineers support the idea of utilizing analysis tools, but need to be paid for the service.
2. Many engineers, and some architects, would like assistance, either direct or financial, for energy simulation modeling.
3. Engineers want an integrated and modular tool so that various design elements can be pulled together without redundancy.

Utilities have a generally good record of intervention.

1. Program failures tend to be remembered more than successes. This can negatively impact utility efforts even when the programs have been completely redesigned.
2. Owners, developers, and designers encourage utility assistance and services, as long as they don't hinder the design and construction process.
3. Owners expressed the desire for more one-on-one communication with their utility representatives.
4. Owners think it's important that the utility programs also be marketed, and provide services, to design professionals; while design professionals indicated that they would have an easier time if the programs were marketed more vigorously to the owners and developers.
5. Utility staff providing design assistance needs to be involved at the beginning and throughout the design and construction process.
6. Utility design assistance needs to be timely and project specific.

Findings About Savings By Design Program

In addition to these general findings about the needs of the market actors, the study (Ref. 2) also developed specific findings about the statewide NRNC program, Savings By Design, which was offered by the three investor-owned utilities in California (SCE, PG&E and SDG&E). The program seeks to change the design practices of professionals in the construction industry by promoting the understanding and use of energy efficient and integrated design techniques in commercial building construction; to increase awareness among building owners of the benefits associated with integrated designs; and to increase the penetration of energy efficient materials, equipment, and systems in the commercial building market.

1. The program effectively serves certain projects and certain types of client. The program pushes the good to better, but not the bad to good.
2. The integration aspect of the program, recognizing and requiring a design team approach is important for achieving program goals.
3. The owner or developer needs to be committed to energy efficiency in order for it to work
4. Owners and developers see the program as a value-added service for their properties.
5. Owner incentives alone are not large enough to guarantee energy efficiency improvements in a project.
6. Utility design assistance is welcome by owners and developers. The reaction from designers was mixed; some were enthusiastic about it, while others were resentful.
7. Designers believe that the program enhances quality and reliability of the energy efficiency aspect of their projects.
8. Most focus group participants were optimistic about the program, but had a few specific concerns:
   (a) Required savings levels will be difficult to achieve.
   (b) The program, which will end in December 2001, does not fit into the timeframe of most new projects.
   (c) Linking the design team incentive to completion of the project is unfair because designers have no control over the construction phase of the project.
   (d) The design team incentive may create a conflict of interest, or a perceived conflict of interest.
9. To overcome these concerns, the participants offered the following suggestions:
   (a) Provide design team incentives in increments throughout design and construction.
   (b) Some suggested providing builder incentives in addition to designer and owner incentives. Others said this wouldn't help.
   (c) Provide design team incentives through the owner.
   (d) Include builders into the design team structure as a prerequisite for any incentives.

NRNC BASELINE EFFICIENCY

Measurement of the energy and demand savings of NRNC programs is sometimes quite important (especially under resource acquisition regimens), and sometimes less important (as under market transformation regimens). The antecedents of the current NRNC MA&E activities were the impact evaluation studies conducted by PG&E and SCE in support of resource acquisition era earnings claims (PY94 and PY96). We have continued using the same methods to measure program savings, to provide data on program effects, and to demonstrate the differences in efficiency between program participants and non-participants.

Overall Building Efficiency

The NRNC studies have produced a dataset of real buildings which represent the energy efficiency characteristics of buildings statewide. Analysis of these buildings provides useful insights. One of our most important observations (Ref. 1) is the following: Most NRNC buildings exceed Title 24[1] energy code requirements.

Our on-site audits and our computer simulations, summarized in Figure 3, tell the story. The graph describes the energy ratio, defined to be the consumption of a building relative to what its consumption would have been under Title 24. An energy ratio of one, indicated by the vertical dashed line, indicates that the building performs at the Title 24 baseline efficiency. An energy ratio below one indicates that the building uses less energy and is more efficient.

Figure 3 shows the distribution of energy ratios for the buildings in four market segments – office, retail, school and public assembly. For example, the figure shows that 11% of new schools in California have an energy ratio of about 0.5; these schools are using about half of the energy that would have been expected if they had been built exactly to the Title 24 requirements.[2]

From the figure itself and the statistical insert, it is clear that the vast majority of the buildings have energy consumption below the Title 24 baseline. Schools were most energy efficient with 90% meeting or exceeding code, followed by offices with about 85% exceeding code. In the public assembly and retail sectors, about 75% exceeded code.

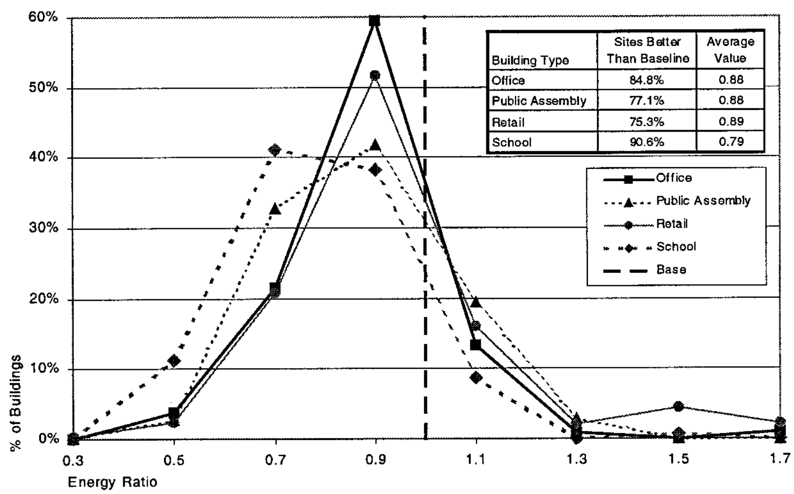

Figure 3: Whole Building Energy Ratio by Building Type

Figure 3 also shows the average value, i.e., the overall energy ratio, in each of the four market segments. The overall energy ratio is the total as-built energy of the entire segment of buildings relative to what the energy would have been if the buildings had been built just to the Title 24 requirements. This confirms that schools have the best overall efficiency. Taken together, they have an energy ratio of 0.79, i.e., they use 21% less energy than code requires. The remaining three segments – offices, retail and public assembly –use 11% to 12% less total energy than code.

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[1] Title 24 is shorthand for California's Building Energy Efficiency Standards, otherwise known as the energy code, which regulates the minimum efficiency of all new construction.

[2] More precisely, our data indicates that 11% of new schools in California have an energy ratio between 0.4 and 0.6.

This kind of information about the distribution of efficiency throughout a population of buildings is relatively rare, because of the large amount data and analysis required to generate it. The statewide MA&E activity has made it possible to compile and study this data from several earlier utility impact evaluation studies.

Prescriptive vs. Performance Approach

One of the questions about NRNC efficiency programs relates to the difference between whole building energy performance versus the energy savings of individual measures. This was reviewed for program years 1994 and 1996 (Ref. 4). The statewide Savings By Design program seeks to encourage whole building energy efficiency, while providing a prescriptive, or "systems" option, based on individual measure efficiencies. The question arises: how many of the participants in the program use the performance method and how many the prescriptive? Which method produces greater energy savings?

The program tracking data generated by the utilities showed an average of 318 MWh annual savings per performance project, or 4.1 kWh savings per square foot. The average annual savings per prescriptive project was 184 MWh and 3.3 kWh savings per square foot. The population data indicates that one should expect performance projects to result in greater energy savings.

Table 1: Summary of Program Tracking Data by Program Approach

	Total Number of Projects	Average kWh Savings per Project	Average kWh Savings per SqFt
Performance	125	318,346	4.1
Prescriptive	1,122	184,233	3.3

Upon analyzing the weighted baseline sample data, it was found that performance projects have a lower energy ratio (defined above) than prescriptive projects, at 0.82 and 0.85 respectively. Performance projects are consuming on average 18% less energy than Title 24, and prescriptive projects are consuming 15% less than Title 24 on average. Performance projects tended to have more fan energy savings and less lighting and cooling energy savings than prescriptive projects. (Ref. 4)

End-Use Savings

What end uses are responsible for energy-efficiency? As shown in Figure 4, the buildings data indicated that about three-fourths of the savings are in the lighting end use. The remaining savings are equally split between cooling and fans. It appeared that most of the cooling and fan savings are due to interaction with the lower lighting loads. However, there is evidence of improved efficiencies in cooling systems.

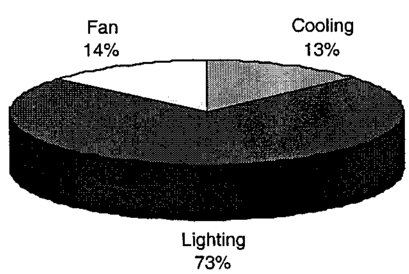

Figure 4: Energy Savings by End Use

Figure 5 shows the lighting usage relative to the Title 24 baseline. The proportion of buildings with lighting better than baseline is essentially the same as the whole building results shown in Figure 3. This supports our observation that the whole-building savings are largely attributable to lighting. Further analysis shows that the lighting efficiency is best in the public sector, followed by the private, owner-occupied sector. Even the speculative buildings have lighting loads 15% less than required under Title 24. The more stringent Title 24 lighting requirements introduced in June of 1999 will narrow the margin for the more efficient sectors and close the margin for the speculative segment.

Similar findings about other end uses are included in the Baseline Study (Ref. 1), and are further explained in Reference 3.

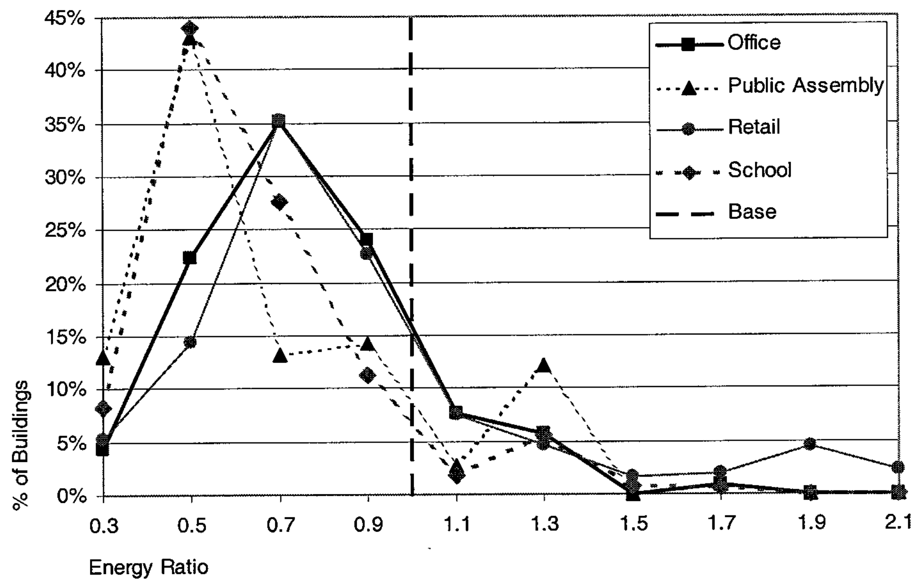

Figure 5: Lighting Energy Ratio by Building Type

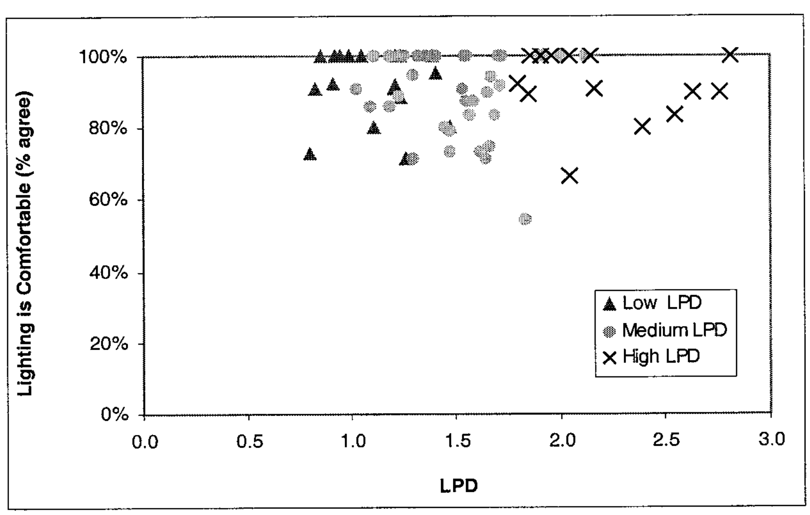

Figure 6. Overall Comfort vs. LPD

Lighting Quality Assessment Findings

One of the questions that has been raised about the low lighting power densities found in California nonresidential buildings (relative to the energy code) is that lighting quality might suffer. Our analysis (Ref. 5) shows that there is virtually no correlation between lighting power density, illuminance uniformity, and occupant satisfaction, at least within the range of conditions observed in our surveys. average illuminance). Figure 6 graphs the relationships between occupant comfort (satisfaction ratings) for three different ranges of lighting power density; there is no discernible pattern to the ratings. High satisfaction ratings were found at all lighting power levels, and the lowest satisfaction ratings do not appear to distinguish between lighting power levels.

BUILDING EFFICIENCY CHANGES OVER TIME

Because we have been able to measure NRNC building efficiencies repeatedly since 1994, we have developed time series data. At the whole building level, this data allows us to talk about overall trends in building energy efficiency. In addition, we have developed end-use and, in some cases, measure specific time series data.

We observed that the NRNC market is slow to change. A typical project takes one to three years from the time the building is designed until it is built and occupied. Furthermore, designers are motivated to standardize their plans and specifications, repeating system designs and choices of equipment that have worked well in previous projects. Change is gradual at the whole building level, as individual systems evolve and as designers experiment with newer design options.

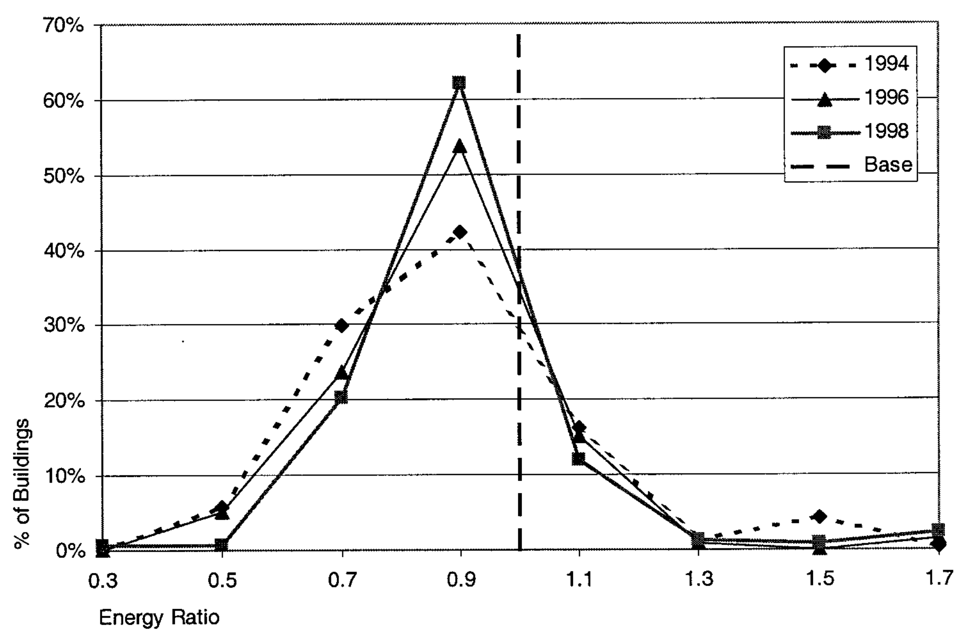

Figure 7: Whole Building Energy Ratio by Year

We asked the designers about changes in the NRNC market in recent years. Most of them confirmed that the market changed gradually. In the last ten years, there were significant changes but only small changes in the last five years (Ref 5).

We also looked for changes in the buildings over time. Figure 7 shows the whole-building energy ratios from 1994 through 1998. The overall energy use relative to baseline did not change significantly. The overall energy ratio was between 0.86 and 0.89 in all three years. However, we did see a significant trend in an improved cooling energy ratio, which dropped from 1.0 to 0.88 and then to 0.75 over the years 1994, 1996 and 1998. This appears to be due to improved efficiency in packaged and built-up cooling systems.

Changes in Title 24 Baseline

Another objective of the NRNC MA&E activity has been to understand the effect of the changes in Title 24; there was a significant upgrade to the energy code in 1998. We have compared the performance of our NRNC dataset of buildings to two different baselines reflecting the 1995 and 1998 Title 24 standards. The biggest change in the 1998 version was new lighting power density requirements and envelope specifications. These changes tend to reduce the baseline lighting, cooling and ventilation energy consumption, while increasing heating energy consumption.

The following are some of the key findings of this study (Ref. 3):

- As expected, the 1998 Title 24 standards raised the bar for new-building energy efficiency. But buildings built between 1994 and 1998 generally met or exceeded the higher standards. More specifically, these buildings were on average almost 8% more efficient than the 1998 baseline. These same buildings were about 14% more efficient than the 1995 baseline.
- Under both the new and prior standards, the majority of the savings were in the lighting end use. Relative to the 1998 baseline, the lighting end use had almost five of the 8% savings. By contrast, relative to the 1995 baseline, the lighting end use had over 11 of the 14% savings. The remaining savings were about equally split between cooling and fans.
- Under the new baseline, lighting power density measures account for four of the 8% savings, daylight controls account for 0.8 and other lighting controls another 0.7, for a total of 5.5% of all savings. This includes the interactive effects of the lighting measures. The remaining savings come from motor measures (1.2%) HVAC measures (0.9%), and shell measures.
- About two-thirds of the savings in the cooling end-use are due to HVAC measures. Most of the remaining cooling savings are due to the indirect effect of lighting measures.
- Under the 1998 baseline, most of the savings in the fan end use are due to motor measures.

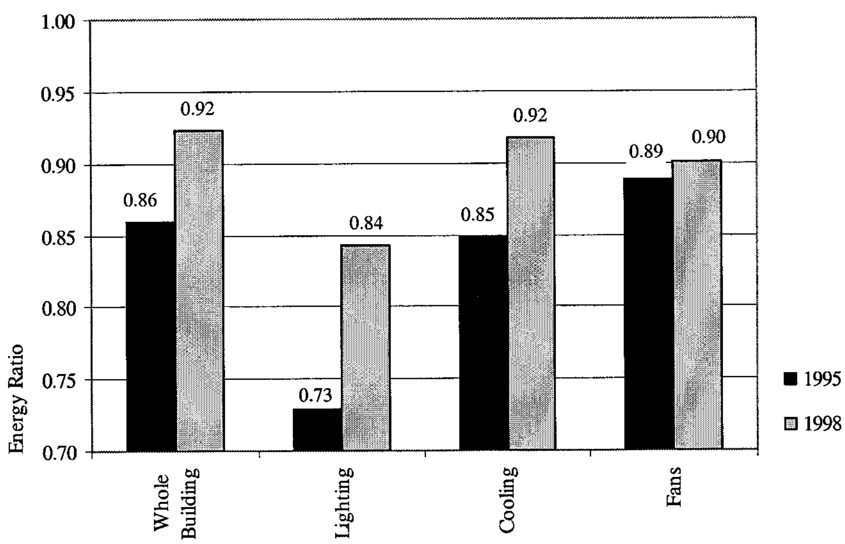

Figure 8: Average Overall Energy Ratio by End Use and T-24 Baseline

Figure 8 shows the average overall energy ratio (defined above) by end use relative to each T-24 baseline. Notice that for all the end uses, on average the buildings are using less energy than both 1995 and 1998 code, indicating that there may be room for making the codes more stringent.

MARKET AND PROGRAM CHANGES OVER TIME

The final piece of the picture in our NRNC MA&E program is to describe how the market and the utility run programs, have been changing over time.

The market characterization part of the MCPAT Study (Ref. 6) consists of developing an understanding of the characteristics of the California NRNC market and its segments. This task entails quarterly data collection to capture and describe changes in the NRNC market. Specifically, F.W. Dodge data[3] were collected quarterly, and reports describing nonresidential construction value and volume, building types, building size, and design team characteristics were produced statewide, and by investor owned utility (IOU) territory. A summary of statewide findings is presented in Table 2.

Table 2. Market Summary for Project Starts in California

Project Type	Quarter	Value ($ billions)	Area (millions of sqft)	Number of Projects
New and additions	Q1, 2000	3.004	48.08	1,160
	Q2, 2000	2.855	39.77	1,096
	Q3, 2000	3.890	46.31	1,227
	Q4, 2000	3.500	45.99	1,191
	Subtotal	13.249	180.15	4,674
Alterations	Q1, 2000	0.710	-	983
	Q2, 2000	0.958	-	1,101
	Q3, 2000	0.959	-	1,425
	Q4, 2000	0.813	-	1,145
	Subtotal	3.440	-	4,654
Total		16.689	-	9,328

F.W. Dodge data indicate that there were over 9,000 nonresidential projects that started construction in California in calendar year 2000, equally divided between new construction and alteration projects. The value of new construction projects, however, was more than four times greater than of alterations. There was little variation in the overall market activity from quarter to quarter, as well as geographically and by building type.

Savings By Design Program Tracking and Penetration

The second objective of the MCPAT Study (Ref. 6) is to track the activities surrounding the Savings By Design (SBD) NRNC program, and to evaluate its penetration levels in the overall NRNC market. The task requires the collection and analysis of the internal tracking system data maintained by each of the IOUs. The tracking systems contain data regarding the number of participants in the SBD

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[3] The F.W. Dodge company reports on construction project starts, building types, square footage and other building characteristics. While there are shortcomings in their data collection methods, they provide the most detailed data available on new construction activity.

program, type and size of projects, geographic locations, energy savings and measures installed through the program.

Results indicate that SBD program participation is high in the building segments with significant market activity, namely office, retail and school. Among the measures installed by program participants, unitary HVAC systems and lighting measures are the most popular. However, whole building design accounts for the highest estimated energy savings in new construction projects, and daylighting and lighting measures produce the highest estimated energy savings in alteration projects.

The SBD program data were used in conjunction with the NRNC market data collected in the Dodge data part of the study to prepare quarterly SBD program tracking and penetration analysis reports. A summary of statewide program penetration is presented in Table 3.

Table 3. Summary of Statewide SBD Program Penetration

Project Type	Quarter	Dodge Area (millions of sqft)	SBD Area (millions of sqft)	% Area Penetration	F.W. Dodge Projects	SBD Participants	% Projects Penetration
New and additions	Q1, 2000	48.08	2.00	4.2%	1,160	19	1.6%
	Q2, 2000	39.77	5.86	14.7%	1,096	70	6.4%
	Q3, 2000	46.31	5.22	11.3%	1,227	74	6.0%
	Q4, 2000	45.99	9.71	21.1%	1,191	152	12.8%
	Subtotal	180.15	22.80	12.7%	4,674	315	6.7%
Alterations (R&R)	Q1, 2000	-	4.01	-	983	26	2.6%
	Q2, 2000	-	2.69	-	1,101	36	3.3%
	Q3, 2000	-	1.82	-	1,425	37	2.6%
	Q4, 2000	-	4.75	-	1,145	86	7.5%
	Subtotal	-	13.27	-	4,654	185	4.0%
Total		-	36.07	-	9,328	500	5.4%

Results for PY2000 indicate that the SBD program captured 6.7% of the nonresidential new construction projects and 4.0% of the R&R projects. By square footage, program penetration into the new construction market is 12.7%, indicating that the program is reaching relatively large buildings. Significant opportunities remain for increased program penetration into the market, for example through sustained networking with the most active designers (also identified in the report).

Net Energy and Demand Savings

For many, the bottom line of NRNC programs is the energy and demand savings. Although the SBD program is officially a market transformation program, to be evaluated by success in meeting predefined milestones, the MA&E activity has the capability, through its extensive and on-going study of buildings, to estimate actual savings from program participants (Ref. 7). The calculations account for the efficiency of SBD program participants, as well as the "naturally occurring" efficiency in the population, as represented by non-participants.

Table 4 presents the net annual energy savings. The program participants were saving approximately 19,387 MWh annually (19.1% savings relative to baseline). In the non-participant population, buildings were better than baseline by 2,332 MWh of annual energy savings (3.9% savings relative to baseline). Taking the difference of these differences, we estimate 15,442 MWh of annual energy savings attributable to the program. These 15,442 MWh of savings represent a net-to-gross ratio of 79.7%.

Table 4: Net Annual Energy Savings – Difference of Differences Method

	Participants	Non-Participants	Participant Net Savings
Baseline (MWh)	101,558	60,028	
As-Built (MWh)	82,171	57,696	
Savings (MWh)	19,387	2,332	15,442
Savings (% of Baseline)	19.1%	3.9%	15.2%
Net-to-Gross Ratio			79.7%

Table 5 presents the net summer peak demand savings. The program participants were saving approximately 5.0 MW (22.0% savings relative to baseline). In the non-participant population, buildings were better than baseline by only 0.7 MW (5.2% savings relative to baseline). Taking the difference of these differences, we estimate 3.8 MW of demand savings attributable to the program. These 3.8 MW of savings represent a net-to-gross ratio of 76.4%.

Table 5: Net Summer Peak Demand Savings – Difference of Differences Method

	Participants	Non-Participants	Participant Net Savings
Baseline (MWh)	22.7	13.4	
As-Built (MWh)	17.7	12.7	
Savings (MWh)	5.0	0.7	3.8
Savings (% of Baseline)	22.0%	5.2%	16.8%
Net-to-Gross Ratio			76.4%

The report from which these findings were taken (Ref. 7) also includes a free-ridership and spillover estimate by measure category, based on a less robust self-report methodology; due to space limitations, these results are not discussed in this paper.

OTHER USES OF THE DATA

In addition to informing program planners and evaluators, the NRNC MA&E data have proven useful in other settings, most notably in the energy code arena. When the California Energy Commission proposed emergency regulations to tighten Title 24 in the fall of 2000, they wanted to know what the statewide energy savings of the new code requirements would be. Because the NRNC buildings dataset includes a statistically representative sample of newly constructed nonresidential buildings across the state, and because there are DOE-2 building energy simulation models for each of the buildings in the sample, the dataset provides an ideal testing ground for the new standards. To generate the statewide estimate, two sets of DOE-2 models were run. In the first set, the efficiency levels of each building in the dataset were set equal to the requirements of the existing Title 24 code requirements. In the second set, the efficiency levels were changed to those of the new requirements. The difference in energy use, represented the energy savings of the code. By applying the statistical weights associated with each building in the sample and adding up the total, a good estimate of the first year's statewide energy savings resulted. In the past, these types of estimates were based on consensus guesstimates about the characteristics of prototype buildings, plus broad assumptions of numbers and types of nonresidential buildings.

The NRNC dataset can be used for more detailed studies of building energy use, such the technical potential of new building technologies and design practices. The dataset can also be used to explore the implications of various utility costing or time of use valuation schemes. It could even be used build models of the NRNC market for use in program planning or evaluation.

References

The following reports have been summarized in this paper, and they are referenced by number throughout. They are listed here in chronological order, as the later reports build on the earlier ones. They of these studies are all available online at www.calmac.org.

1. RLW Analytics, Inc. "Non-Residential New Construction Baseline Study." A California State-Level Market Assessment and Evaluation Study prepared for Marian Brown, Southern California Edison Co., July 8, 1999.

2. Heschong Mahone Group. "Market Transformation Barriers and Strategies Study." Prepared for Marian Brown Southern California Edison Co., Statewide NRNC MA&E Program, Douglas Mahone, Catherine Chappell, Program Managers, February, 2000.

3. RLW Analytics, Inc. "Updated Baseline Compared to 1998 T-24 Code & End Use Savings by Measure Category - A Follow-on to the Nonresidential New Construction Baseline Study - Project 1."
A California State-Level Market Assessment and Evaluation Study prepared for Marian Brown, Southern California Edison Co., Douglas Mahone, Catherine Chappell, Program Managers, November 15, 2000.

4. RLW Analytics, Inc. "Prescriptive vs. Performance Projects Comparison - A Follow-on to the Nonresidential New Construction Baseline Study - Project 2." A California State-Level Market Assessment and Evaluation Study prepared for Marian Brown, Southern California Edison Co., Douglas Mahone, Catherine Chappell, Program Managers, January 29, 2001.

5. Heschong Mahone Group. "Lighting Quality & Measurement Error Assessment - A Follow-on to the Nonresidential New Construction Baseline Study - Project 3." A California State-Level Market Assessment and Evaluation Study prepared for Marian Brown, Southern California Edison Co., Douglas Mahone, Catherine Chappell, Program Managers, February 14, 2001.

6. Quantum Consulting, Inc. "NRNC Market Characterization and Program Activities Tracking Report PY2000." Additional quarterly reports prepared beginning Q1, 2000. Prepared for Marian Brown Southern California Edison Co., Statewide NRNC MA&E Program, Douglas Mahone, Catherine Chappell, Program Managers, April 2001.

7. RLW Analytics, Inc. "Building Efficiency Assessment Quarterly Report - 4th Quarter 1999 through 3rd Quarter 2000." A California Statewide Market Assessment and Evaluation Study prepared for Marian Brown, Southern California Edison Co., Douglas Mahone, Catherine Chappell, Program Managers, June, 2001.