KENNY C. GUINN
Governor

STATE OF NEVADA

CARL B. LINVILL
Director

OFFICE OF THE GOVERNOR
NEVADA STATE OFFICE OF ENERGY
727 Fairview Drive, Suite F
Carson City, NV 89701

Final Report – Volume I
In-Field Residential Energy Code Compliance Assessment and Training Project

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Funded by the United State Department of Energy, Office of Energy Efficiency and Renewable Energy to Nevada State Office of Energy in partnership with Sierra Pacific Power Company, Nevada Power, and the International Conference of Building Officials

Report Prepared by: Britt/Makela Group, LLC
Eric Makela, Study Project Leader and Report Author
Michelle Britt, Report Author

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SECTION 1.0 ABSTRACT

This report provides specific information on the process and findings for the *In-Field Residential Energy Code Compliance Assessment and Training Project* partially funded by the U.S. Department of Energy (Grant #DE-FG51-00R02119). Initial work on the study began in December of 2000 with final reporting completed in June, 2003. The primary goal of the grant project was to increase code enforcement effectiveness for those jurisdictions that have adopted an energy code. A secondary goal was to provide building code officials and home builders alike with the information needed to understand how typical construction practice compares with the requirements of the 1992 edition and subsequent editions of the Model Energy Code and the International Energy Conservation Code. This fundamental understanding is necessary to support consideration of code update adoption.

The project partners consisted of the International Conference of Building Officials (now the International Code Council) serving as project principal investigator, with project cost share, oversight, and technical support provided by the Nevada State Office of Energy and Nevada's two sister investor-owned electric utilities, Nevada Power and Sierra Pacific Power Company. A residential baseline study was conducted on 200 single family homes in Northern and Southern Nevada (eight building department jurisdictions total) to determine how typical single-family homes in the state of Nevada compared to current energy codes and also to identify potential energy code compliance problems related to both plan documentation and building practices. Training was provided to jurisdictions that participated in the study.

The study collected energy efficient building data from building plans and as-built data collected on the construction site. The U.S. Department of Energy's MECcheck Energy Code Compliance software was used to analyze each of the buildings and compare them against the 1992 through 1995 Model Energy Code and the 1998 and 2000 International Energy Conservation Code. One jurisdiction included in the study in Northern Nevada had previously adopted the 1995 Model Energy Code with all other jurisdictions enforcing the 1986 Model Energy Code. The average rate of compliance for homes included in the study in Northern Nevada are included in Table 1.1

Average MecCheck Results
1992 MEC -10.96%
1993 MEC –10.96%
1995 MEC –42.09%
1998 IECC –42.09%
2000 IECC –42.09%

Table 1.1

The compliance rate in Southern Nevada jurisdictions was significantly greater than Northern Nevada (see Table 1.2). This can be attributed to the region wide adoption of the 1992 Model Energy Code by Southern Nevada jurisdictions, the reduction in the level of stringency in Model Energy Code and International Energy Conservation Code in warmer climates, and the strong influence of market based, above-code programs in the Southern Nevada region.

Average MecCheck Results	
1992 MEC	11.82%
1993 MEC	10.36%
1995 MEC	9.12%
1998 IECC	9.12%
2000 IECC	9.12%

Table 1.2

SECTION 2.0 INTRODUCTION

The report that follows provides specific information on the process and findings for the *In-Field Residential Energy Code Compliance Assessment and Training Project* partially funded by the U.S. Department of Energy (Grant #DE-FG51-00R02119). Initial work on the study began in December of 2000 with final reporting completed in June, 2003. The primary goal of the grant was to increase the energy code adoption rate within the jurisdictions in the state of Nevada, and to increase code enforcement effectiveness for those jurisdictions that have adopted an energy code. A secondary goal was to provide building code officials and home builders alike with the information needed to understand how typical construction practice compares with the requirements of the 1992 edition and subsequent editions of the Model Energy Code and the International Energy Conservation Code. This fundamental understanding is necessary to support consideration of code update adoption. A residential baseline study was conducted to determine how typical single-family homes in the state of Nevada compared to current energy codes and to identify potential building practice and energy code compliance documentation problem areas.

SECTION 3.0 PROJECT OVERVIEW

The state of Nevada adopted the 1986 edition of the CABO Model Energy Code (MEC) by reference with minor state amendments in 1988. This code is applicable only where the local jurisdiction has not adopted an energy code. Despite numerous attempts, the Nevada State Office of Energy has been unable to receive legislative authority to upgrade Nevada's minimum building energy efficiency standards to a more recent version of the MEC or IECC as recommended by the US DOE EPAct requirements.

As of the writing of this report, only a few jurisdictions in the state have adopted the 1995 MEC (City of Reno and Washoe County) even though most are enforcing the 1997 Uniform Building Code and several are looking to update to the more current International codes. The City of Las Vegas, Clark County, City of Henderson and City of North Las Vegas have adopted the 1992 MEC and are enforcing the commercial provisions (except lighting energy efficiency) as presented in the adopted energy code (ASHRAE 90A-1980). The City of Reno is the only jurisdiction that is enforcing the full range of requirements from the ASHRAE 90.1-1989 commercial energy code.

The Nevada State Office of Energy proposed to assess the current quality, and rate of compliance of energy efficient construction practices relative to the 1992 and 1995 CABO Model Energy Code and the 1998 and 2000 ICC International Energy Conservation Code. The International Conference of Building Officials (now the International Code Council) was identified to serve as project principal investigator; while project cost share, oversight, and technical support would be provided by the Nevada State Office of Energy and Nevada's two sister investor-owned electric utilities, Nevada Power and Sierra Pacific Power Company. The study was designed to answer the following questions:

1. How does current residential construction in the state of Nevada compare to the 1992 to 1995 Model Energy Code and 1998 to 2000 International Energy Conservation Code from both a plan review and inspection standpoint?

2. What does a typical home look like from an efficiency standpoint in Northern and Southern Nevada?

3. What typical efficiency upgrades will be necessary to show compliance with the energy codes for those non-compliant buildings?

4. Do the buildings in the field match what is shown on the plans and documentation?

5. What are some of the problem areas for demonstrating compliance with the energy code?

Section 3.1 Project Design

The data collection project was designed to be straight forward and sequential in nature. Composition of the data collection team was based upon member interest in the level of efficiency measures installed in current construction within Nevada, expertise in the problems in current construction practice in meeting the energy code requirements, and the ability to provide education to the plan review and field inspection staff that participated in the study. A brief description of the steps used in the data collection process are described below. A more thorough description is included in Appendix III of the report, along with a listing of individuals serving as members of the data collection teams.

Section 3.1.1 – Development of Survey Instrument. A data collection form was developed to collect both MEC-compliance and building practice quality data from the residential building plans and field visits. The form was developed to guide the user through the process of collecting data with the ability to satisfy both the needs of plan review and field inspection data collection. The plan review form was based on the U.S. Department Of Energy's MEC*check* energy code compliance software, which was used as the data analysis tool. A page was added to collect blower door and pressure pan data from each of the tested houses.

Section 3.1.2 – Selection of Jurisdictions for Data Collection and Training. Two areas of the state were targeted for data collection and training. The largest population center in the northern portion of the state is the Reno Metropolitan are that primarily includes the jurisdictions of Reno, Sparks, Carson City, and Washoe County. The southern Nevada population center is focused in Las Vegas, and includes the jurisdictions of Las Vegas, North Las Vegas, Henderson and Clark County. Based on population for the two regions, the goal was to select 140 single family homes in Southern Nevada and 60 homes in Northern Nevada to include in the study. The following jurisdictions were initially targeted for participation in the study due to population and building permit activity:

Northern Nevada	***Southern Nevada***
City of Reno	City of Las Vegas
City of Sparks	City of Henderson
Carson City/County	City of North Las Vegas
Lyon County	Clark County
Washoe County	Mesquite

All of the jurisdictions in Northern Nevada that were pre-selected for the study agreed to participate. In Southern Nevada, the cities of Henderson and North Las Vegas and Clark County participated with the City of Las Vegas declining to participate. Mesquite dropped from the sample when it was determined that Nevada Power staff could not offer project support to Mesqite, the latter being outside Nevada Power's service territory, and thus preventing cost-effective data collection by the other half of the collection team.

Section 3.1.3 – Notification of Jurisdictions. A letter inviting participation into the study was sent to all of the jurisdictions that were pre-selected. The letter provided basic information concerning how the study would be conducted and also what the jurisdiction's responsibilities were if they agreed to participate in the study. The estimated number of homes that each jurisdiction needed to select for the study was stated in the letter along with parameters for selecting the homes. As an incentive to participate in the study each jurisdiction was provided with one free day of energy code training for their staff.

The letters were followed by phone calls to ensure that the jurisdictions would in-fact participate in the study and to schedule the on-site data collection.

Section 3.1.4 – Perform Data Collection at the Selected Jurisdictions. The data collection process was divided into two phases. Data was first collected from the building plans during the "plan review" phase of the study. One data collection person performed a plan review at each of the building department offices in Northern Nevada where as in Southern Nevada a two-person team was sent into each jurisdiction on several occasions. Two-person teams were used in Southern Nevada due to the number of plans that had to be pulled for review in each jurisdiction. Mike Berry, Home Energy Rating Service, served as the team lead in Southern Nevada and Eric Makela, Britt/Makela Group (formally ICBO), served as the team lead in Northern Nevada.

Each of the jurisdictions provided building plans for active, "typical" subdivision projects of local production home builders, based on the need of the project and willingness of the builder to participate in the study. Data collection was then performed on the building plans and energy code compliance documentation (if provided). Data collection included calculating areas of the building envelope (e.g. wall, glazing and roof area) documenting insulation R-values and glazing U-factors, and determining if information on non-insulation and glazing elements of the building (e.g. vapor retarders and air sealing were included) on the plans. Builder contact information was also collected from the building plans to schedule the on-site inspections.

Following the plan review process, each of the builders was contacted to schedule the onsite data collection. This part of the study included a correlation/verification of the data collected during the plan review phase of the project and collecting data that did not show up on the building plans (e.g. glazing U-factor). A blower door and pressure pan test was also conducted on each of the homes where access was granted by the builder. Two person teams were typically used in Northern Nevada with Jim Taylor, Energy Rated Homes of Nevada, taking the lead in contacting and scheduling the inspections. Southern Nevada also used a two-person team to conduct the on-site inspections and testing, as lead by Mike Berry.

A portion of the homes were replaced in the original sample in Northern Nevada due to the home either not being available for inspection and testing, difficulty contacting the builder, or builders who selected not to participate in the study and did not allow the teams out on the building site. These homes were replaced by additional homes in the study to ensure that the sample size did not change. For Southern Nevada, a field inspection was conducted on only 13 homes from the original sample. The low results were due to difficulty in making contact with the individuals that could grant permission to collect data onsite, lack of builder interest in the study and suspicion concerning a perceived link between the results of the study and possible construction defect litigation.

As a direct result of the inability to collect data in Southern Nevada, a contract was put in place with Woods & Associates, a code compliance and U.S. EPA Energy Star program home inspector/rater in Las Vegas, to provide data for 100 typical homes in Southern Nevada sample region. A mix of Energy Star qualifying homes and standard construction homes were included in the sample. Each of the homes included a blower door test. Table 4.1 in the study provides specifics on the sample from Northern and Southern Nevada.

Section 3.1.5 – Data Analysis. Once the data was collected, each of the homes was input into the MEC*check* Energy Code Compliance Tool to determine the compliance margin for various years of the MEC and IECC. Data collected during the plan review process was input first. If information on efficiency levels was incomplete, basic assumptions were used to complete the model using levels of efficiency typically found in the region. Each of the homes was compared against the 1992, 1993 and 1995 Model Energy Code and 1998 and 2000 International Energy Conservation Code.

Data for each of the field inspected homes was then entered in the MEC*check* software to determine compliance margins with each of the code years referenced in the preceding paragraph. As with the plan reviewed homes, assumptions were made using typically construction practice in the region if levels of efficiency were not available. The next step in the process entailed examining each non-compliant house and adding conservation features to the building until it complied with the code. For each region, a list of typical efficiency upgrades was developed that would be added to the noncompliant house until compliance was met with the applicable code year. The results of this exercise will provide important data to local code jurisdictions that may evaluate building industry impacts related to adoption of energy code updates. The results of the data analysis is reported in Section 4 of this report for the state as a whole, Northern Nevada and Southern Nevada. Levels of efficiency were compared for each region of the state because of differing construction practices between Northern and Southern Nevada**.**

Section 3.1.6 – Deliver One-Day of Training to Each Jurisdiction. As an incentive to participate in the study, each jurisdiction was provided with one day of training on an energy code topic of their choice. This included training on energy codes as they apply to either residential or commercial buildings. The intent behind the training was to increase enforcement on the residential and/or commercial provisions of the energy codes currently adopted by the jurisdictions.

Six-days of training were provided to the jurisdictions in Northern and Southern Nevada covering both the residential and commercial provisions of the energy code. In addition to these training sessions, one-day of training covering the residential and commercial provisions of the 2000 IECC were provided to the mechanical code review committee in Southern Nevada who were responsible for recommending adoption of the mechanical and energy codes. Also, a field inspection course was developed and delivered to jurisdictions in Northern Nevada that focused on how to inspect for the residential provisions of the 1995 Model Energy Code. The training was held on location at an active, major community subdivision project.

Section 3.1.7 – Draft Report with Findings of the On-site Survey. Section 4 and Section 5 of this report provide detailed information on the findings from the plan review and field inspection portion of the study.

SECTION 4.0 STATE WIDE GENERAL REPORTING

Section 4.1 Number of Plan Check and Field Checks per Jurisdiction

Overall, eight (8) jurisdictions participated in the study including five (5) from Northern Nevada and three (3) from Southern Nevada. An additional one hundred (100) homes were added to the sample from Southern Nevada in increase the number of data points field data (see Table 4.1). The additional homes were divided into two categories:

- Energy Star and Engineered for Life homes, and
- Standard Construction, i.e. those homes that were not intended to meet the Energy Star criteria or to be built above the energy code.

Table 4.1 provides a summary of the number of homes for each jurisdiction that had been both plan reviewed and inspected, plan reviewed only with no inspection, and the population of homes that are considered field inspected only (Energy Star and Engineered for Life Las Vegas Metro Area and Standard Construction Las Vegas Metro Area).

Section 4.1.1 Northern Nevada. An original sample of sixty (60) homes was selected for Northern Nevada with the assumption that each of jurisdictions would select twelve (12) homes for the study. Each of the homes selected were to represent typical construction for the jurisdiction and no more than three homes were to be selected from any one development.

A portion of the original sample selected for the study could not be used for each of the jurisdictions. There were several reasons for the homes falling out of the sample including:

- Inability to contact the builder to gain access to the site for inspection and testing; and/or
- Lack of availability of selected plan or model for inspection and testing e.g. the builder had discontinued the selected home and was not planning on building more, or had built out the related subdivision and sold/occupied the model home

Additional homes were selected from each jurisdiction to complete the sample. In some cases, it was difficult to maintain the original sample size within a jurisdiction due to a lack of available homes from different builders. For example, the full sample size for Carson City and Lyon County was not achieved but more homes were selected in Reno, Sparks and Washoe County to complete the sample size for the region.

Jurisdiction	Plan Check and Field Inspected Homes	Plan Check Only, No Field Inspection	Energy Star and Engineered for Life Las Vegas Metro Area	Standard Construction Las Vegas Metro Area
Carson City/County	8	9	0	0
Lyon County	12	9	0	0
Reno	13	3	0	0
Washoe County	14	2	0	0
Sparks	12	8	0	0
Henderson	2	36	0	0
North Las Vegas	8	31	0	0
Clark County	3	35	0	0
Misc. S. Nevada		0	48	52
Totals	72	133	48	52

Table 4.1

Section 4.1.2 Southern Nevada. An original sample of 140 homes was selected for Southern Nevada with the assumption that each of jurisdictions would select 35 homes for the study. As with Northern Nevada, each of the homes selected were to represent typical construction for the jurisdiction and no more than three homes were to be selected from any one development.

The participation from each jurisdiction selected in the study was very high but follow-up builder approval to gain access to the building sites was extremely low. Only the City of Las Vegas, selected during the original sample, declined to participate in the study citing manpower constraints. This reduced the sample size in Southern Nevada to 105 with the intention that additional data would be collected to offset the 35 homes that fell out of the study. Sources for further data were additional jurisdictions, and including data from private industry providing Energy Star and energy code compliance services within Southern Nevada.

Only 12 of the 102 selected for the study, or 12 percent, had both plan review and on-site inspection. An on-site inspection could not be conducted on the remaining 90 homes due to the following reasons:

- Inability to contact the builder to gain access to the site, and
- Permission was denied to conduct the on-site data collection and testing.

Several attempts were made to contact the builders or their representatives to gain access to the building site including requests presented to industry members at a Southern Nevada Home Builders Association codes Committee meeting, but all attempts were unsuccessful. No additional homes were selected to offset the homes that were dropped from the sample, as was done in Northern Nevada. This decision was made because of budgetary and time constraints. The project partners felt is was more cost effective to take an alternate course to gather data and meet the needs of the study than to continue to try to gain access to the building sites.

Section 4.1.3 – Energy Star and Standard Construction Practice Homes. Because of the lack of success in gaining access to the building sites in Southern Nevada, it was decided to use an Energy Star and Energy Code Compliance provider in Southern Nevada to collect additional data. Woods & Associates was contacted and subsequently agreed to provide data for an additional 100 homes. Forty-eight homes that qualified for the Energy Star and Engineering for Life programs were subsequently included in the study in addition to 52 homes built to local code requirements and standard construction practices more typical of Southern Nevada. No formal plan review was conducted by the data collection staff so this population of homes is considered field verified only. Complete data was provided for each of the residences consistent with the data collected during the plan review process for the other home population samples.

Section 4.1.4 Databases

1. Primary Database – includes field inspection data for all homes for which both plan checks and field inspections were conducted – Sample size 72.

2. Plan Check Database – includes plan check data for all plan check only homes and plan check data for homes that were also field inspected – Sample size 205.

3. Southern Nevada Energy Star Database – includes data from Energy Star and Engineered for Life homes in the Las Vegas Metropolitan Region – Sample size 48.

4. Southern Nevada Standard Construction – includes data on Standard Construction homes in the Las Vegas Metropolitan Region – Sample size 52.

Section 4.2 Code adopted for Each Jurisdiction

Several residential building energy codes are being enforced within the state of Nevada. The minimum state wide residential energy code is the 1988 Nevada state energy code (Nevada Administrative Code, Chapter 523, *Regulations for the Conservation of Energy in New Building Construction*, adopted on July 8, 1999 and based on the 1986 Model Energy Code). Of the jurisdictions that were sampled in Northern Nevada, the following codes were found to be enforced:

Carson City: 1988 Nevada state energy code

Lyon County developed simplified code (R11 in the wall system and R38 in the roof assembly or R13 in the wall assembly and R-30 in the roof assembly)

City of Reno: 1995 MEC

Washoe County: 1988 Nevada state energy code

City of Sparks: 1988 Nevada state energy code

It is important to note that this study was not intended to compare rates of compliance with energy codes other than the 1992 through 1995 Model Energy Code and 1998 and 2000 International Energy Conservation Code. No comparison was conducted to determine rates of compliance with the 1988 Nevada state energy code or the Lyon County-developed code.

All of the jurisdictions sampled in Southern Nevada have adopted the 1992 Model Energy Code.

Section 4.3 Percentage of plans with energy documentation submitted, R-Values and U-Factors on Plans

One of the goals of the energy code baseline study was to determine if information was being included on the plans or in the documentation included with the plans to determine compliance with the energy code. This is required under Section 104 of the MEC and IECC. During the plan review process each set of building plans were checked to determine if documentation was submitted with the plans and/or if information on the insulation R-values or Glazing U-factors were included on the building plans.

Section 4.3.1 Documentation Submitted. Each jurisdiction has policies and procedures that dictate the type of information that they need to see for each submittal for permit. This will vary according to the code adopted and jurisdictional policies. The study revealed that energy code compliance documentation was provided in seven out of eight jurisdictions that were included as part of the sample. Documentation was typically provided more frequently to the jurisdictions in Southern Nevada than in Northern Nevada. Again, based on the energy code adopted, study researchers found there was a variety of documentation submitted in Northern Nevada. In the City of Reno, the U.S. DOE MECcheck compliance documentation was submitted in the majority of the cases. Homes in Carson City/County, Washoe County and City of Sparks had documentation showing compliance with the 1988 Nevada state energy code as well as MECcheck. In some cases the Chapter 4 Performance Based software MICROPAS was used to demonstrate compliance with the code. Lyon County did not require compliance documentation due to the simplicity of their code. The documentation typically provided information on the levels of efficiency assumed for the building, which would meet the intent of the code.

	Documentation Submitted	R-Value on Plan	U-Factor on Plans
Carson City	29%	5.26%	5.26%
Lyon County	0%	57.14%	0.00%
City of Reno	100%	0.00%	0.00%
Washoe County	50%	50.00%	0.00%
City of Sparks	60%	30.00%	0.00%
City of Henderson	84%	13.16%	2.63%
Clark County	92%	34.21%	7.89%
City of North Las Vegas	100%	0.00%	0.00%

Table 4.3

Section 4.3.2 R-value and U-factors on the Building Plans. The plans were also checked for insulation R-values, Glazing U-values, and other energy code compliance information. In several cases, if compliance documentation was submitted with the plans, the insulation R-values and glazing U-factors were not called out on the plans; this is consistent with policy in some jurisdictions. Insulation R-values that were called out typically were called out for foundations e.g. crawlspace wall insulation, wall systems and roof assemblies. Frequently, insulation was shown in the construction detail or the cross section of the building but the R-value was not specified. Glazing U-factors were almost never identified on the building plans. Typically, the types of windows were called out (e.g. double pane, vinyl framed windows) but not the U-factor. When determining compliance rates, the values shown in the documentation superceded those shown on the building plans if the documentation values are more stringent than those on the plans.

The majority of the plans did not contain plan notes requiring the building to be sealed for air leakage, duct insulation levels, nor were there plan notes about recessed can lighting being IC Rated and air tight, a requirement in the 1995 MEC and later.

Section 4.4 - Compliance Rates for the Insulation and Glazing Requirements

The U.S. Department of Energy's MEC*check* Energy Code Compliance (Version 3.3, release 1b) software was used to determine if the building complied with a particular year of the Model Energy Code or the International Energy Conservation Code. Each of the homes were modeled using data collected from the building plans during the Plan Check process and then were analyzed again based on the data collected in the field.

Section 4.4.1. Plan Check Code Compliance Analysis. The Plan Check analysis was conducted based on the information collected from the building plans and documentation and listed in Table 4.4.1. A compliance margin for each plan-reviewed house was determined based on each of the code editions specified in Table 4.4.1. Assumptions were made during the plan review analysis stage if there was not enough information on the plans to complete the input file. This was only the case with insulation R-values, glazing U-factors and heating and cooling efficiency. Floors over a vented crawlspace or garage were assigned an R-19. Glazing U-factors for Northern Nevada were assigned a 0.55, which is the default value from Table 102.5.2(1) of the 2000 IECC for vinyl windows, which are typical in the region. The default table was used because the IECC requires default values to be used if the U-factor is not called out in the plans or documentation. Default U-factors for exterior doors were taken from Table 102.5.2(2) of the 2000 IECC. The efficiency values from the documentation were always used if there were discrepancies between the documentation and the building plans.

The compliance rates for Northern Nevada were not unexpected since only the City of Reno has adopted the 1995 MEC. Overall the compliance rates for the City of Reno were higher than the other jurisdictions, even though they still averaged less than zero (-8.32% percent worst than code for code edition 1992 – 1993 and –26.04% worst than code for the 1995 – 2000). The compliance margins were higher during the 1992 and 1993 code editions for two primary reasons. The thermal requirements went up slightly between the 1993 and 1995 code editions, which impacted the compliance rate somewhat. The other more significant reason for the decrease in compliance rates was due to the placement of insulation in crawlspace walls. The typical construction practice for insulating crawlspaces in Northern Nevada is to insulate the crawlspace wall and passively ventilate the crawlspace. Crawlspaces must be ventilated to the outside per the 1997 Uniform Building Code (97 UBC). The 1992 and 1993 MEC allow this practice to be used to meet the thermal requirements of the code. The practice of insulating the foundation was only allowed in the 1995 and later years if the crawlspace did not communicate to the outside, i.e., not passively ventilated, and because the 97 UBC requires all crawlspaces to be ventilated, insulation in crawlspace walls cannot be counted toward energy code compliance starting in the 1995 MEC code edition. Therefore, those single family homes that showed insulation on the crawlspace walls were modeled without any insulation in the floor when compared with the 1995 MEC and 1998 and 2000 IECC.

The City of Reno had the highest rate of documentation submitted of those that participated in the study but frequently the house was incorrectly documented. Documenting incorrect assembly areas was the greatest problem that was found during the examination of the plans and documentation. The documentation showed the buildings complying with the 1995 MEC but once the values were corrected, the compliance rates dropped significantly. MEC*check* compliance documentation was typically submitted with the plans in Reno. Overall Lyon County had the lowest rate of compliance due to their energy code requirements and lack of compliance information on plans or attached documentation.

The compliance rates within Southern Nevada were significantly greater than those in Northern Nevada. The City of North Las Vegas was the only jurisdiction that had a negative rate of compliance in later code editions. All of the jurisdictions complied on average with the 1992 and 1993 MEC. Enforcement was one reason for a greater rate of energy code compliance. The 1992 MEC has been enforced in Southern Nevada since 1995 so jurisdictions and builders are aware of the requirements. Because the MEC and IECC are based on Heating Degree Days and does not consider cooling, requirements for insulation R-values and glazing U-factors are less than the northern part of the state. This makes complying with the code easier. In addition, because of the presence of an energy code-compliance-documentation industry within Southern Nevada, the accuracy of the documentation was greater than that submitted in Northern Nevada. Of interest is the difference in compliance margin between 1992 and 1993. The requirements for roof/ceiling insulation raised slightly during these two code edition editions for warmer climates, having an adverse impact on the compliance margins.

Table 4.4.1 – Energy Code Compliance Rates

	Code Editions									
	1992		1993		1995		1998		2000	
	Plan Check	Field Inspection	Plan Check	Field Inspection	Plan Check	Field Inspection	Plan Check	Field Inspection	Plan Check	Field Inspection
Carson City	-19.27%	-0.79%	-19.27%	-0.79%	-61.11%	-39.16%	-61.11%	-39.16%	-61.11%	-39.16%
Lyon County	-23.22%	-22.02%	-23.22%	-22.02%	-76.58%	-68.00%	-79.67%	-68.00%	-79.67%	-68.00%
City of Reno	-8.32%	-8.63%	-8.32%	-8.63%	-26.04%	-33.78%	-26.04%	-33.78%	-26.04%	-33.78%
Washoe County	-17%	-8.84%	-17%	-8.84%	-44.68%	-27.10%	-44.68%	-27.10%	-44.68%	-27.10%
City of Sparks	-15.60%	-11.70%	-15.60%	-11.70%	-36.24%	-44.61%	-36.24%	-44.61%	-36.24%	-44.61%
Clark County	4.82%	12.80%	3.19%	11.20%	1.56%	9.63%	1.31%	9.63%	1.31%	9.63%
City of Henderson	7.01%	12.30%	5.41%	11.20%	3.57%	8.90%	3.57%	8.90%	3.57%	8.90%
City of North Las Vegas	4.16%	11.34%	2.35%	9.85%	-0.04%	8.99%	-0.04%	8.99%	-0.04%	8.99%
Las Vegas Metro Energy Star		10.32%		9.28%		7.21%		7.21%		7.21%
Las Vegas Metro Standard Construction		6.26%		5.33%		3.74%		3.74%		3.74%
Study Average	-4.37%	1.91%	-5.23%	1.22%	-20.38%	-10.61%	-20.93%	-10.61%	-20.93%	-10.61%

Section 4.4.2 Field Inspection. The compliance margin for each house was also determined based on data collected in the field. Using field data to determine the compliance margin was an important goal of the study as this determined if the built home actually met the energy code instead of just the home as represented on the building plans and documentation. The values entered on the data collection forms used during the plan review portion of the study were verified in the field and corrected as needed. These values were then used to determine the realized rate of compliance for each code edition.

Based upon the field inspection data in Northern Nevada the rate of compliance with the code increased an average of 6.26% for the 1992 and 1993 code editions and an average of 6.40% for the 1995, 1998 and 2000 code editions. For the 1992 and 1993 code editions Carson City demonstrated the greatest change from –9.27% worse than-code to –0.70% worse than-code or an 18.48% increase in compliance rate. Washoe County also increased significantly by 8.16%. The City of Reno was the only jurisdiction that experienced a decrease in the compliance rate between the plans and documentation (-0.31% decrease). As stated above, this can be attributed to improperly completed documentation during the plan review process.

The County of Washoe and Carson City both experienced significant increases in the compliance rate when compared to the 1995, 1998 and 2000 code editions. The compliance rate for Washoe County increased by 17.58% with the Carson City increasing by 21.95%. The city of Reno experienced a 7.74% decrease in compliance margins. One of the contributing factors in the decrease is that the building plans are showing insulation placed in the building subfloor, as required by the city of Reno, however, site inspections found the insulation is actually being place in the crawlspace walls. The overall increase in compliance rate in Northern Nevada points to the fact that the efficiency levels of insulation and glazing that are installed in the building are greater that what is shown on the building plans. For example, vinyl windows are typically installed on homes in Northern Nevada and have a U-factor of approximately 0.50. However, the default for these same windows that was used in the plan review portion of the study had a U-factor of 0.56.

The results for Southern Nevada were similar to those in Northern Nevada but due to the low number of homes that were plan reviewed and inspected, it is difficult to draw conclusions. Table 4.1 includes the total number of homes where data was taken for both plan review and inspection. The Field Inspection results displayed in Table 4.4.1 were based on two houses for the City of Henderson, eight houses for Clark County and three houses for North Las Vegas. Based on an aggregate there was an increase of 6.96 percentage points between the plan reviewed and field inspected buildings when compared against the 1992 and 1993 MEC. Of the data collected, Clark County experienced the greatest increase with an average of 8.00 percentage points and the City of Henderson the least with 5.54 percentage points. For code editions ranging from 1995 to 2000 the average increase was 1.46 percentage points. Clark County showed an increase of 8.07 percentage points and the City of North Las Vegas showed an increase of 9.03 percentage points.

The lower percentage point increases in Southern Nevada versus Northern Nevada can be attributed to more information being shown on the plans and/or compliance documentation. Therefore the accuracy of the plan review analysis was higher in Southern Nevada as fewer assumptions were made during the modeling. Still, the overall data indicates that the levels of efficiency installed in the field are frequently greater than those shown on the plans or attached documentation.

Section 4.4.3 Energy Star and Standard Construction Data. The compliance rates (based on field data only) for the population of homes designed to comply with the Energy Star Program and/or Engineered for Life Programs were on average lower than the small population of homes that that were field surveyed directly by study participation within Southern Nevada. On average, this population of homes had a compliance rate of 1.75% lower than the field inspected homes in the survey built to code. There were several reasons for the lower compliance margins for these homes. The Energy Star homes used a Chapter 4 Systems Performance Approach to demonstrate compliance with the code. This approach considers both the heating and cooling load of the building on an annual basis. In addition, this approach can also account for a reduction of infiltration into the building. The MEC*check* compliance tool only considers the thermal efficiencies of the building envelope and is based on Heating Degree Days.

Under the Chapter 4 approach, the building shell can be slightly less efficient from and insulation and glazing standpoint but more efficient by reducing the infiltration load and installing low Solar Heat Gain Coefficient Glazing to offset the cooling loads.

The sample of Standard Construction homes provided by Woods & Associates also had a compliance rate that was on average lower than the field inspected sample. On average, based on an aggregate of all code edition years, the difference between the Standard Construction houses and the field inspected sample was a 5.58 percent compliance rate. While it is difficult to draw conclusions between the Woods & Associates Standard Construction homes and the field inspected homes from the original Southern Nevada sample, a comparison can be drawn between the Woods & Associates Standard Construction homes and the original Southern Nevada Plan Check data. On average, the homes included in the Southern Nevada Plan Check sample had a rate of compliance of only 1.55 percent better than the population of Woods & Associates Standard Construction homes, which is extremely small given the size of the population.

SECTION 5.0 REGIONAL ANALYSIS SUMMARY

The analysis that follows is divided between Northern Nevada and Southern Nevada. A primary goal of the study was to determine the typical efficiency levels for a home built in Northern Nevada and Southern Nevada. The regions were separated during the design of the study because of the differences in climate and construction practices between the two parts of the state. For example, most homes in Northern Nevada use a vented crawlspace foundation primarily for cost and freeze protection. Southern Nevada homes are typically built on slab-on-grade. Heating is the primary space conditioning load on Northern Nevada, as typical Heating Degree Day values are approximately 6,000 HDD. Cooling is the prime space conditioning load in Southern Nevada with the HDD values at approximately 2,500. The discussions that follow only relate the specific region as a whole. The findings for each jurisdiction that participated in the study are found in Appendix 1.

Section 5.1 Northern Nevada

The analysis that follows for Northern Nevada is based on the following sample size:

- Total Plan-Reviewed Houses- 90
- Total Field Inspected Homes (Homes have been both plan-reviewed and field inspected) – 59
- Total Homes Only Plan-reviewed - 41

As stated earlier in this report, a portion of the original homes selected for the study was replaced. Data from these homes were included where possible in the plan-reviewed portion of the analysis but were not included in the analysis for the field checked homes.

Section 5.1.1. Typical Northern Nevada House. Figure 5.1.1 displays the average levels of efficiency found in the residential building sample in Northern Nevada. The averages are based on the information collected in the field versus that collected during plan review. In addition to the levels of efficiency, the rates of compliance with the Model Energy Code and International Energy Conservation Code are also listed for the entire sample as a whole.

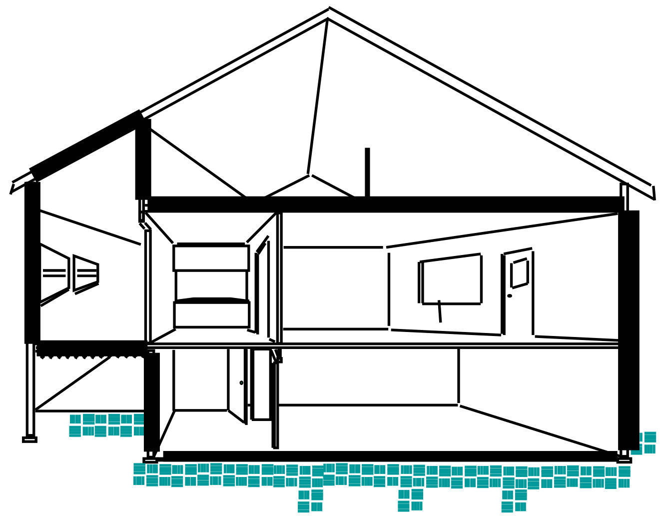
Summary of Findings – Northern Nevada
Figure 5.1.1
Based on Field Inspection – Sample Size of 59

Primary Roof: All Wood
Rafter/Joist Truss – 100%

Average Ceiling Insulation R-Value – 33.52

Average Glazing
Square Footage-361

Primary Walls: Wood
Frame, 16” o.c. –
100%



Typical Glazing – Vinyl
Double Pane 68%

Average Wall
Insulation
R-Value – 15.67

Typical Heating System- Gas
Heating 100%
Average AFUE- 88%

Average Glazing:Wall
Area Ratio-16%

Typical Entrance Door –
Fiberglass Insulated 68%

Typical Cooling System- Air
Cooled Air 88%
Average SEER- 10

Foundation: Crawlspace
Insulated Wall – 75%

Average Insulation
R-Value – 12.67

Average Square
Footage: 2017

<u>Average MecCheck Results</u>

1992 MEC -10.96%
1993 MEC –10.96%
1995 MEC –42.09%
1995 MEC –42.09%
1998 IECC –42.09%
2000 IECC –42.09%

Section 5.1.2 Determining Increases in Efficiency to Demonstrate Compliance with Different Code editions. One of the goals of the study was to determine the incremental increases in level of efficiency required to bring a noncompliant home into compliance with the particular code edition. The first step in the process was to determine typical upgrades in efficiency that could be used to bring up the level of compliance. These were based on regional construction practices and cost. To ensure consistency the upgrades were added in order (starting with lowest cost first) until compliance was demonstrated for a particular home. For example, if a building already had insulation installed in the raised floor over a crawlspace, the first upgrade would be to increase he ceiling insulation to R-38. If the building did not comply, or if the ceiling already had an R-38 ceiling insulation, the next upgrade was to model more efficient windows and decrease (increase the efficiency) the window U-factor to 0.40. No changes were made to the window area, assembly areas or volume of the building

The goal was to gain compliance for the structure to a level, which could be defined as a zero (0) percent compliance margin or better. For example if adding the feature raised the margin from a –5% worse-than-code to a +2% better-than-code the analysis ended and the results recorded. No attempt was made to “optimize” the model to reduce the compliance margin down to minimal code compliance or zero. For Northern Nevada the following upgrades were determined:

Buildings with Raised Floor Insulation Already Installed. A portion of the homes already had insulation installed in the raised floor over a crawlspace and these needed to be analyzed separately from those homes were insulation was to be placed in the crawlspace wall. This was due to the change in the code requirements in the 1995 MEC, which prohibited insulation, placed in the crawlspace wall if the crawlspace communicated to outside air.

Upgrade One – Ceiling Insulation to R-38

Upgrade Two – Window U-factor to U 0.40

Upgrade Three – Furnace Efficiency to 90 AFUE

Upgrade Four – Wall R-value to R-19

Buildings with Crawlspace Wall Insulation. Efficiency upgrades for homes with insulation placed on the crawlspace walls were divided up into two code edition categories. The 1992 and 93 code editions allowed this installation so the efficiency increases mimicked those in the category discussed above. However, when evaluating homes for the 1995 through 2000 code editions the efficiency increases first started with the placement of insulation in the floor over the crawlspace because the home modeled for compliance with the 1995 code edition assumed no insulation in the floor.

1992 – 1993 MEC

Upgrade One – Ceiling Insulation to R-38

Upgrade Two – Window U-factor to U 0.40

Upgrade Three – Furnace Efficiency to 90 AFUE

Upgrade Four – Wall R-value to R-19

1995 MEC – 2000 IECC

Upgrade One – Raised Floor Insulation to R-19

Upgrade Two – Ceiling Insulation to R-38

Upgrade Three – Window U-factor to U 0.40

Upgrade Four – Furnace Efficiency to 90 AFUE

Upgrade Five – Wall R-value to R-19

			Improvements Needed to Comply (Listed in Order of Upgrades)								
						1	2	3	4	5	
Average Compliance Rate			Total Sample Size	Total Non-compliant Homes	Floor Insul. To R-19	Ceiling Insul. To R-38	Window U-factor To U-0.40	Furnace Efficiency To 90 AFUE	Wall Insul. To R-19	Slab Edge Insul. To R-10, 18”	Crawlspac e Wall Insulation
Code edition	Plan Check	Field Inspection									
1992	-17.03%	-10.96%	59	48	1	27	45	31	2	2	3
1993	-16.82%	–10.96%	59	48	1	27	45	31	2	2	3
1995	-49.21%	–42.09%	59	48	43	29	47	33	3	2	0
1998	-50.38%	–42.09%	59	48	43	29	47	33	3	2	0
2000	-50.38%	–42.09%	59	48	43	29	47	33	3	2	0

Table 5.1.2 – Efficiency Upgrades to Demonstrate Compliance

Table 5.1.2 displays the conservation feature upgrades required to demonstrate compliance with each of the code editions for the population of homes. The table also displays the total number of occurrences that each conservation feature was added to a home to show compliance with a particular year of the code. For example, 48 homes did not comply with the 1995 MEC. Of these homes, 43 homes were required to change from crawlspace wall insulation to insulation over the crawlspace if the insulation was not placed in the floor on the original design. The remaining five already had insulation placed in the crawlspace floor. Twenty-nine of the homes were required to increase the ceiling insulation levels to an R-38 if it was not included in the original design. As the next step, 47 of the noncompliant homes were required to increase the window efficiency to a U-factor of 0.40. If compliance was not reached after this upgrade, the furnace efficiency was increased to a 90% AFUE furnace. This was required for 33 of the homes. Increasing the wall insulation level to an R-19 was the final upgrade. Only two of the homes were required to make this modification.

For the 1992 and 1993 code homes 65% of the non-compliant homes were required to install the following energy efficiency package to gain compliance:

- Ceiling Insulation: R-38
- Window U-factor: U-0.40
- Furnace Efficiency 90 AFUE

For this same population of homes 94% required the following upgrade:

- Ceiling Insulation: R-38
- Window U-factor: U-0.40

Sixty-nine percent of the homes compared required the following upgrades to comply with the 1995 through 2000 code editions:

- Installing R-19 Raised Floor Insulation versus Crawlspace Wall Insulation

- Ceiling Insulation: R-38
- Window U-factor: U-0.40
- Furnace Efficiency: 90.0 AFUE

For the same population of homes, 98 percent required the following efficiency upgrades to comply with the 1995 through 2000 code:

- Installing R-19 Raised Floor Insulation versus Crawlspace Wall Insulation
- Ceiling Insulation: R-38
- Window U-factor: U-0.40

The upgrade packages presented in this report represent only one option selected to demonstrate compliance with the various code editions. Based on the compliance approach used, the packages may differ as the documentation author optimizes the compliance package based on the building configuration.

Section 5.1.3. Foundation System. The primary foundation type for sample population of homes in Northern Nevada is vented crawlspaces with the insulation placed in the crawlspace wall (see Table 5.1.3). Insulation placed in the crawlspace floor accounted for only 18.64% of the homes in the sample.

Primary Foundation Type	
Crawlspace Wall Insulation	74.58%
Slab	6.78%
Crawlspace Insulated Floor	18.64%
	100.00%

Table 5.1.3(1)

Of those homes that installed insulation on the crawlspace walls, the average area was 354.98 square feet of stem wall area. This area is required for input into the MEC*check* software (see Table 5.1.3(2)).

Primary Foundation Area/Linear Ft.	
Crawlspace Wall Insulation	354.98
Slab	178.00
Crawlspace Insulated Floor	2543.45

Table 5.1.3(2)

Table 5.1.3(3) shows the average insulation R-values for insulation placed on the crawlspace wall, slab perimeter and insulation placed in the crawlspace floor for both the Plan Check and Field Inspection portion of the study. Note that on average higher insulation levels were called out on the building plans for insulating the crawlspace walls than was found in the field, but only by a slight margin. For insulation placed in the crawlspace floor the insulation installed in the field was on average higher than that called out on the plans.

Primary Foundation R-Value		
	Plan Check	Field Inspection
Crawlspace Wall Insulation	12.0	11.8
Slab	0.0	0.0
Crawlspace Insulated Floor	17.11	20.7

Table 5.1.3(3)

Determining insulated crawlspace wall insulation placement is necessary for compliance with the energy codes. The MEC*check* software requires four inputs that are included in Table 5.1.3(4) and Figure 5.1.3(1). From a building code standpoint, the distance from the top of the exterior grade line to the top of the footing will be at least 6 inches less than the from the top of the footing to the top of the stem wall as shown in line A and B in Figure 5.1.3(1). Study project inspections found that inside of the footing was not often covered with soil and the insulation went down past the top of the footing as shown in Dimension Line C and Dimension Line D.

Primary Foundation Insulation Dimensions A, B, C and D Field Inspection Only – Measured in Feet

	Dimension A	Dimension B	Dimension C	Dimension D
Crawlspace Wall Insulation	1.89	1.31	1.99	0.06

Table 5.1.3(4)

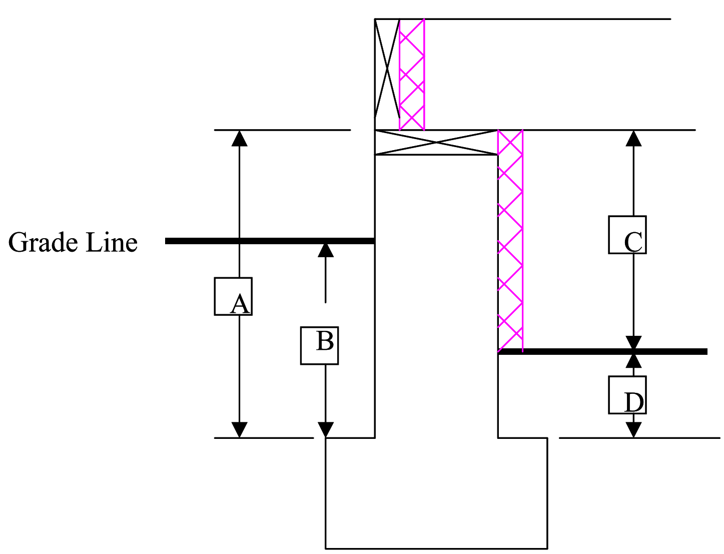


Figure 5.1.3(1)

Approximately 15% (9) of the homes surveyed had more than one foundation type (see Table 5.1.3(5)). Of those homes that included a secondary foundation type, 75% included a floor over an unconditioned garage. A small number of homes also had a slab-on-grade in addition to the primary foundation type.

Foundation System		Insulation R-Value	
	Field Inspection	Plan Check	Field Inspection
Slab	25%	NA	0
Crawlspace Insulated Floor	75%	17.79	12.0
	100.00%		

Table 5.1.3(5)

Section 5.1.4 Exterior Wall Information. Three types of wall systems were documented within the study. Exterior walls were considered walls between the conditioned space and the outdoors. Secondary wall systems were defined as walls between the conditioned space and an attached garage. Tertiary walls were defined as the wall between the conditioned space and the ventilated attic or more commonly referred to as an attic kneewall. This condition occurred in homes with vaulted ceilings.

Exterior wall Systems.

All of the exterior wall systems found in Northern Nevada consisted of the following construction practice:

- Framing Type – Wood studs 16” on-center spacing
- Average Area – 1841.24 Gross Square Feet
- Weighted Average of Insulation R-value –
  - Plan Check – 15.9
  - Field Inspection - 16.0

Insulation R-value was documented during the plan check and field inspection portion of the data collection process. The differences were documented in the data collection form. Based on the field data, the insulation installed in the field was on average higher than what was shown on the plans or documentation.

The insulation placement varied within the wall systems. Insulation was always placed in the stud cavities within the walls. A portion of the time rigid board insulation was also placed over the face of the studs to increase the R-value. Rigid board insulation was used if Exterior Insulation Finish Systems (EIFS) were installed on the home as a stucco system. Often this was called out as an optional siding package on the building plans and might vary based on the home in the tract development or the orientation of the building on site.

Secondary Wall Systems.

Fifty-six of the homes included in the survey included an attached garage and therefore included an insulated wall between the house and the garage. The secondary wall systems found in the study consisted of the following construction practice:

- Framing Type –all walls are 16” o.c. wood studs
- Area – 290.23 Gross Square Feet
- Weighted Average of Insulation R-Value
    - Plan Check – 14.0
    - Field Inspection – 14.0
    -

The insulation placement was always between the framed cavities.

Tertiary Wall Systems.

Forty of the homes surveyed included attic kneewalls as defined above. The tertiary wall systems found in the study consisted of the following construction practice:

- Framing Type –all walls wood trusses
- Average Area – 120.66 Gross Square Feet
- Weighted Average of Insulation R-Value
    - Plan Check – 14.5
    - Field Inspection – 14.0

The insulation placement was always between the framed cavities. The slight difference between the average insulation R-value between the Plan Check data and Field Inspection data can be attributed to higher R-values called out on the building plans versus what was found out in the field. Also, if the insulation R-value was not called out on the building plans for the attic kneewall, which was often the case, the R-value was assumed to be the same as the exterior wall cavity R-value.

Section 5.1.5 Roof Information. Data on roof systems was collected to determine the average roof area and insulation R-value. Typically, the primary roof system was considered the system that was predominantly used in the home, for example, a vented attic. If a home used both standard truss systems for a flat ceiling and then a scissor truss system for a vaulted ceiling, these were combined into one roof system as they both include a vented attic. For Northern Nevada the primary roof system consisted of:

- Framing Type –All Wood Joist Rafter Truss Systems
- Average Area – 1793.27 Square Feet
- Weighted Average of Insulation R-Value
    - Plan Check – 32.2
    - Field Inspection – 33.7
- Distribution of Insulation R-Values
    - R-38 Insulation: 26, or 44% of the structures
    - R-30 Insulation: 33, or 56% of the structures

A small percentage of the buildings included a secondary roof system. This was typically a vaulted, cathedral style roof with no vented attic. Only four of the residential buildings had secondary roof systems. These roof systems are categorized as follows:

- Framing Type - Wood Joist Rafter Truss Systems
- Average Area – 665.50 Square Feet
- Weighted Average of Insulation R-Value

  - Plan Check – 30.0
  - Field Inspection – 37.2
- Distribution of Insulation R-Values
  - R-38 insulation: 3, or 75% of the structures
  - R-30 insulation: 1, or 25% of the structures

The framing depth of the rafters that were insulated with R-38 insulation were not verified in the field to determine if the one-inch air space between the insulation and roof sheathing was maintained.

Section 5.1.6 Window/Skylight Information. Information on window type, glazing efficiency and glazing area was collected during both the Plan Check and Field Inspection portion of the study. As reported earlier in the report the majority of the plan reviews did not include information on window type, thus study analysis relied on assumptions made in for the plan review documentation and data collected by the field collection team. NFRC labels were the source of U-factors, in the absence of NFRC labels study analysis relied on default U-factors for the type of window (for example vinyl, low-e) observed in the field.

Primary Window Type

Table 5.1.6(1) provides information about the primary window type found in the field. The primary window type was defined as the predominant glazing type found in each of the houses. The primary window type was primarily an operable window. The table is based on the percent of occurrence based on number of homes inspected. Vinyl windows were the predominant window type in Northern Nevada.

Primary Window Type	Field Inspection
Unidentified	28.81%
Metal	1.69%
Vinyl	67.80%
Vinyl Low E Argon	1.69%

Table 5.1.6(1)

The primary window type had the following characteristics:

- Average Square Feet Glazing Area
  - Plan Check – 294.35
  - Field Inspection - 316.52
- Weighted Average U- Factor
  - Plan Check - .54
  - Field Inspection - .48

A default U-factor was applied to the window if no U-factor was identified in the field. The default U-factor was taken from Table 102.5.2(1) of the 2000 International Energy Conservation Code. The default U-factor was applied to four of the homes sampled in Northern Nevada. All of the windows in the primary window sample were double glazed.

The study found two primary differences between the glazing shown on the plans and that found in the field: the glazing area on plans was less than that found in the field; and the U-factors documented during plan review were on average greater (less efficient) than the actual U-factor found in the field. The latter discrepancy was primarily due to the lack of information on the building plans concerning glazing efficiency. Default U-factors were assumed based on Table 102.5.2(1) of the 2000 International Energy Conservation Code if the values were not called out on the plans.

Secondary Window Type.

Several houses within the sample included secondary windows that either were fixed or glass block. Table 5.1.6(2) was based on the percent of occurrence based on number of homes inspected.

Secondary Window Type	Field Inspection
Unlabeled	29.17%
Metal	8.33%
Vinyl	58.33%
Glass Block	4.17%

Table 5.1.6(2)

The secondary window type had the following characteristics:

- Average Square Feet Glazing Area
  - Plan Check – 76
  - Field Inspection - 78.68
- Weighted Average U- Factor
  - Plan Check - .57
  - Field Inspection - .45

A default U-factor was applied to the window if no U-factor was found in the field. The default U-factor was taken from Table 102.5.2(1) of the 2000 International Energy Conservation Code. A default U-factor of .50 was used for the default U-factor was applied to four of the homes sampled in Northern Nevada.

On average the glazing area documented in the field was greater than what was shown on the building plans or documentation. The glazing U-factor information taken from the building plans was on average greater (less efficient) than the actual U-factor found in the field. This was primarily due to the lack of information on the building plans concerning glazing efficiency. Default U-factors were assumed based on Table 102.5.2(1) of the 2000 International Energy Conservation Code if the values were not called out on the plans.

Skylight Type.

Two of the buildings in the sample included skylights. These were recorded during both the plan check process and verified in the field. Table 5.1.6(3) shows the area and U-factor for each occurrence. A default U-factor was used for each of the skylights, as there were no NFRC labels found in the field.

Primary Skylight Type	Square Feet	U-factor
Metal	110	1.89
Vinyl Framed	30	0.84

Table 5.1.6(3)

Section 5.1.7 Door Information. The type and area of doors either located in the exterior wall, or in the wall between the house and garage, was recorded during the plan check process and the field inspection process. Only the data recorded in the field was included in this report as there was typically no information included on the building plans for exterior doors. Solid core, self-closing garage doors were typically called out on the building plans.

Main Entrance Doors.

Table 5.1.7(1) includes information on the main entrance door to the house. The primary door type in Northern Nevada was a steel foam core door (49.15%). The average area for the entrance doors was 22.89 square feet. A typical 3-foot wide entrance door is approximately 20 square feet. Several of the doors found on the larger homes were 8 foot in height or included double 3 foot X 7 foot double doors. The weighted average U-factor for the entrance doors was 0.39. A default U-factor was assumed in 59.23 % of the structures. Table 102.5.2(2) of the 2000 IECC was used to determine the U-factors. No storm doors were reported in the study.

Main Entrance Door - Type	
Fiberglass Ins	6.78%
Glass	3.39%
Steel foam core	49.15%
Wood w 7/16	3.39%
Wood w 9/8	1.69%
Wood	1.69%
Solid core flush	22.03%
Unlabeled	1.69%

Table 5.1.7(1)

Garage/House Door.

Table 5.1.7(2) includes information on the door to the garage. The typical door type in Northern Nevada was a solid core flush door (86.21%). Solid core doors are typically installed to meet the building code requirements. The average area for the doors to the garage was 18.18 square feet. A typical 2’10” foot wide door is approximately 18 square feet. A portion of the doors found on the larger homes were 8 feet in height. The weighted average U-factor for the entrance doors was 0.39. A default U-factor was assumed in 62% of the structures. Table 102.5.2(2) of the 2000 IECC was used to determine the U-factors. No storm doors were reported in the study.

House/Garage Doors	
Fiberglass Ins	0.00%
Glass	0.00%
Steel foam core	10.34%
Wood w 7/16	0.00%
Wood w 9/8	0.00%
Wood	3.45%
Solid core flush	86.21%
Unlabeled	0.00%

Table 5.1.7(2)

Other Exterior Door.

Several of the homes included a second door leading from the interior to the outside through the exterior wall. Of these, approximately 69% were glass French doors (69.23%). The average door size was 35.92 square feet. The average U-factor was 0.76.

Other Exterior Doors	
Glass	69.23%
Steel foam core	7.69%
Half Light	23.08%

Table 5.1.7(3)

Section 5.1.8 Duct Information - Field Inspection Only Data. The jurisdictions in Northern Nevada did not require mechanical plans to be submitted for the permit process. Therefore, information concerning the duct system was collected during the field inspection process. Data was collected for both the return and duct systems.

Return Duct System.

The location of the return ducts, the type of duct material type of sealant and duct insulation R-value was recorded during the field inspection portion of the study. The majority of the return systems were located in the attic (86%). The remaining return systems were located in either the crawlspace or a combination of the attic and crawlspace.

Eighty eight percent of the return ducting was recorded as flexible duct. The remaining 12% consisted or a combination of sheet metal and flexible ducting, or could not be determined in the field because it was concealed.

An important element of the study looked at the method of duct sealing that was used on the return duct systems. Table 5.1.8(1) provides the frequency of each type of duct sealant method that was found in the field. The use of unlisted and labeled duct tape (Sealant Duct Tape) was found on 52.54% of the systems. Often duct tape was used in combination with of zip ties. Listed and labeled tapes (UL 181 Tape) were found in the field on approximately 35% of the return duct systems. In less than 2% of the systems was mastic used as the sealant.

Sealant Use	
Return Duct Sealant UL181 Tape	35.59%
Return Duct Sealant Mastic	1.69%
Return Duct Sealant Mastic+Tape	1.69%
Return Duct Sealant Duct Tape	52.54%
Return Duct Sealant Zip Ties	25.42%
Return Duct Sealant Screws	3.39%

Table 5.1.8(1)

The insulation R-Value found on all flex type ducts had an insulation level of 4.2. Three of the duct systems that used sheet metal had an R-value of R-3.5. One of the systems was insulated to an R-8.

Supply Duct Systems.

The location of the supply ducts, the type of duct material type of sealant and duct insulation R-value was recorded during the field inspection portion of the study. Table 5.1.8(2) shows the distribution of duct locations. Nearly 46% of the supply ducts were located in the attic, 38.98% were located in the crawlspace, and in approximately 5% of the houses were the ducts located in both the crawlspace and attic.

Supply Duct Location	
Attic	45.76%
Crawlspace	38.98%
Both	5.08%

Table 5.8.1(2)

Eighty-nine percent of the supply ducting was recorded as flexible duct. The remaining 11% consisted or a combination of sheet metal and flexible ducts or could not be determined in the field because it was concealed.

The study looked at the method of duct sealing that was used on the supply duct systems. Table 5.1.8(3) provides the frequency of each type of duct sealant method that was found in the field. The use of unlisted and labeled duct tape (Sealant Duct Tape) was found on 49.15% of the systems. Often duct tape was used in combination with of zip ties. Listed and labeled tapes (UL 181 Tape) were found in the field on approximately 38.98% of the supply duct systems.

Sealant Use	
Supply Duct Sealant UL181 Tape	38.98%
Supply Duct Sealant Mastic	1.69%
Supply Duct Sealant Mastic+Tape	1.69%
Supply Duct Sealant Duct Tape	49.15%
Supply Duct Sealant Zip Ties	25.42%
Supply Duct Sealant Screws	3.39%

Table 5.8.1(3)

The insulation R-Value found on all flex type ducts had an insulation level of 4.2. Three of the duct systems that used sheet metal had an R-value of R-3.5. One of the systems was insulated to an R-8.

Section 5.1.9 Mechanical System. This section reports on data found during the field inspection portion of the study because of the lack of mechanical plans submitted during the plan check process. Typically, the jurisdictions in Northern Nevada did not require the applicant to submit mechanical plans for permit.

Furnace Efficiency.

The majority of the heating systems in the homes that were surveyed used gas furnaces for the heating source. One of the buildings used a gas boiler and radiant heating system. The gas boiler had an AFUE of 80%. The average AFUE for the gas furnaces surveyed was 80.6. If the furnace efficiency was not available, a default efficiency of 78% was used. Approximately 30.5% of the furnaces surveyed used the default value. Three of the homes surveyed had two furnaces with an average AFUE of 82.66%.

Cooling Efficiency.

Eighty-eight percent of the structures had vapor compression air conditioning. The average SEER for the systems was 10 for the primary cooling systems. Four of the homes included secondary cooling systems. Of these, one included as system with an efficiency of 12 SEER, one of the systems had an efficiency of 10.5 SEER and the other two were assumed to be a minimum of 10 SEER. One of the homes used a radiant heating system (see above). The average for the four homes was also a SEER of 10. If the SEER of the system could not be determined on-site, the system was assigned a minimum SEER of 10. This occurred on 50% of the homes. If the condensing unit had not been installed at the time of inspection, but it was evident that the system would be installed in the future, the system was given an assumed efficiency of 10.0.

Section 5.1.10 Air Leakage Testing. Each of the field inspected homes was blower door tested to determine the Natural Air Changes Per Hour (nACH) at 50 Pascals. A Pressure Pan Duct Leakage Test was also conducted in each of the homes to determine if the heating and cooling system ductwork were tight or leaky. The pressure pan test provided a good indication of how well the ducts were installed and sealed.

Blower Door Testing.

The average Natural Air Changes Per Hour for each of the homes tested was .37 nACH. As a comparison, the 1995 Model Energy Code assumes a nACH of .51 for the standard or “code house”. The testing was conducted in homes that were typically at, or near, the final inspection. The sheetrock had been installed, and the weatherstripping had been installed around all of the windows and doors located in the exterior walls and those leading to the garage. If the weatherstripping had not been installed on the doors during the time that the buildings were tested, tape was used to seal up the leakage points. Table 5.1.10(1) shows a frequency distribution of the homes tested and the calculated nACH. The majority of the homes (49%) tested in the .30 - .39 nACH range with over 76% of the homes testing at less than .40 nACH.

Natural Air Changes Hour (nACH) Results – 50 pascals	
nACH Ranges	# Of Homes
.20 - .29	16
.30 - .39	29
.40 - .49	9
.50 - .59	1
.60 - .69	2
.70 - .79	1
1.10 – 1.19	1
Total Homes	59

Table 5.1.10(1)

Average Pan Pressure.

A pressure pan test was conducted at each of the supply and return registers in each field inspected sample. This test was conducted to determine the relative leakiness of the duct system. Average supply and return pressure differences were determined for each of the home in the study and for each jurisdiction while depressurizing the home to 50 Pascals. In Northern Nevada, the average pressure pan test for the supply ducts was 6.0 Pascals. For return ducts, the average pressure difference was 7.6 Pascals.

Pressure Difference (Pa)	Condition of Duct System
0.0	Completely Airtight
0.5	Very Small Duct Leakage
1.0	Small Duct Leakage
3.0	Moderate Duct Leakage
8.0	Large Duct Leakage
15.0	Very Large Duct Leakage
30.0+	Open to the World

Source – State of Idaho Gemstar Certified High Performance Duct System Diagnostic Procedures

Table 5.1.10(2)

Table 5.1.10(3) shows a frequency distribution based on the pressure pan readings for both supply and return ductwork. For supply ducts, a pressure difference between 2.0 – 2.9 was the predominate reading. Return ducts were predominantly between a pressure difference of between 5.0 – 6.9 pascals. A portion of the high readings was due to catastrophic air leaks found out on-site following the pressure pan tests. The return leakages were partly due to the use of framing cavities to serve as part of the return air system.

Condition of Duct System	Supply	Return
0 - .9	6	0
1.0 – 1.9	9	4
2.0 – 2.9	12	7
3.0-3.9	7	5
4.0-4.9	2	5
5.0-5.9	4	9
6.0-6.9	1	10
7.0 – 7.9	3	2
8.0 – 8.9	3	1
9.0 – 14.9	4	9
15 +	6	5

Table 5.1.10(3)

Section 5.2 Southern Nevada

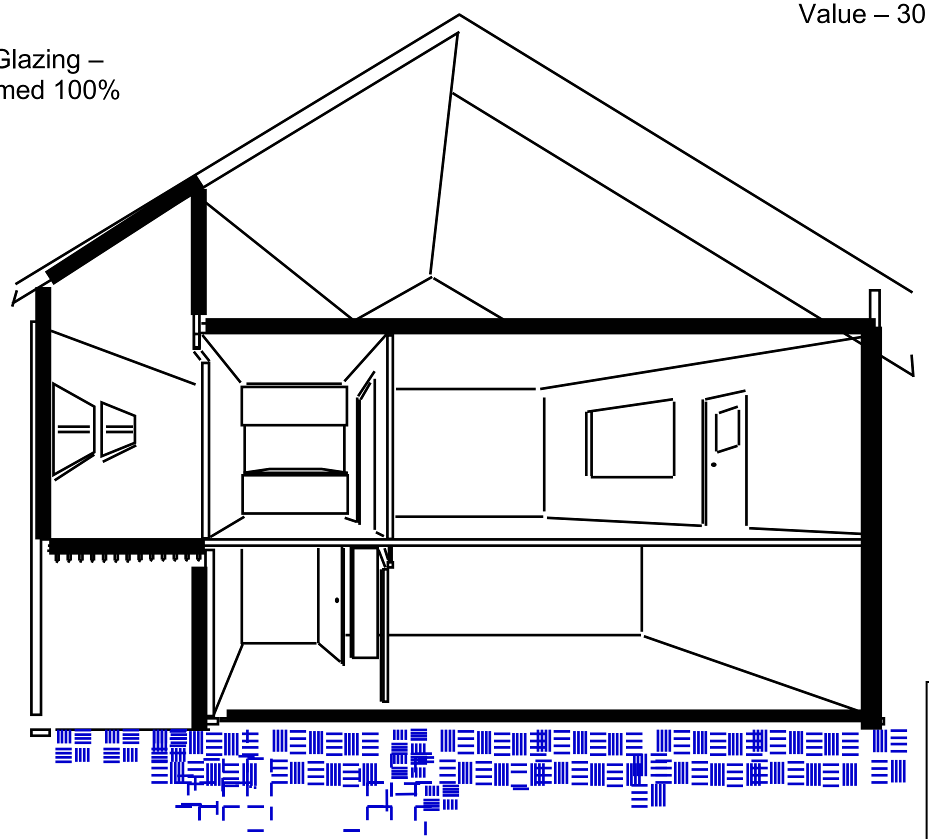
The analysis that follows for Southern Nevada is based on the following sample size:

- Total Plan-reviewed Houses- 115
- Total Field Inspected Homes (Homes have been both plan-reviewed and field inspected) – 13
- Total Homes Only Plan-reviewed - 102

As stated earlier in the study, the majority of the homes that were selected during the plan check portion of the study were not available for field inspection. Data from these homes were included where possible in the plan-reviewed portion of the analysis but were not included in the analysis for the field checked homes. The analysis that follows is based on a limited data set.

Section 5.2.1. Typical Southern Nevada House. Figure 5.2.1 displays the average levels of efficiency found in the residential building sample in Southern Nevada. The averages are based on the information collected in the field versus that collected during plan review. In addition to the levels of efficiency, the rates of compliance with the Model Energy Code and International Energy Conservation Code are also listed for the entire sample as a whole.

Summary of Findings – Southern Nevada
Figure 5.2.1
Based on Field Inspection – Sample Size of 13



Average MecCheck Results

1992 MEC 11.82%
1993 MEC 10.36%
1995 MEC 9.12%
1998 IECC 9.12%
2000 IECC 9.12%

Section 5.2.2. Determining Increases in Efficiency to Demonstrate Compliance with Different Code Editions. All homes within the Southern Nevada data set that were field inspected complied with all versions of the energy code. The intent of the study was to determine typical upgrades to these structures of they did not meet the thermal requirements for a particular code edition but because of the positive compliance margins, this was not necessary.

Section 5.2.3. Foundation Systems. The primary foundation for all homes in the study's sample population in Southern Nevada is slab-on-grade construction with no insulation placed on the slab edge. Slab edge insulation is not a requirement of the 1992 Model Energy Code in the jurisdictions surveyed in Southern Nevada. The average linear feet of slab edge was 169 feet.

Five of the homes surveyed had secondary foundation systems. Typically, this was a floor over a garage in a two-story home. All of the homes installed R19 insulation between the framing. The plan reviewed sample had an R-value average of 19.2.

Secondary Foundation Type	Secondary Foundation Area (sq.ft)	Secondary Foundation R-Value	Secondary Foundation Insulation Type
Crawlspace Insul Floor	475	19	Cavity
Crawlspace Insul Floor	526	19	Cavity
Crawlspace Insul Floor	515	19	Cavity
Crawlspace Insul Floor	512	19	Cavity
Crawlspace Insul Floor	231	19	Cavity

Table 5.2.3

Section 5.2.4 Exterior Wall Information. As with Northern Nevada three types of wall systems were documented within the study. Exterior walls were considered walls between the conditioned space and the outdoors. Secondary wall systems were defined as walls between the conditioned space and an attached garage. Tertiary walls were defined as the wall between the conditioned space and the ventilated attic or more commonly referred to as an attic kneewall. This condition occurred in homes with vaulted ceilings.

Exterior wall Systems.

All of the exterior wall systems found in the field inspected homes in Southern Nevada consisted of the following construction practice:

- Framing Type –Wood studs 16" on-center spacing
- Average Area
  - Field Inspected - 1902.77 Gross Square Feet
  - Plan Reviewed (Total Population) – 2098.94 Square Feet
- Weighted Average of Insulation R-Value
  - Plan Check – 14.5
  - Field Inspection – 16.2

Insulation R-value was documented during the plan check and field inspection portion of the data collection process. The differences were documented in the data collection form. Based on the field data, the insulation installed in the field was on average higher than what was shown on the plans or documentation. On average the total exterior wall area for the population of plan reviewed homes was higher than those homes that contained both field inspection and plan review data.

The insulation placement varied within the wall systems. Insulation was always placed in the stud cavities within the walls. A portion of the time rigid board insulation was also placed over the face of the studs to increase the R-value. Rigid board insulation was used if Exterior Insulation Finish Systems (EIFS) were installed on the home as a stucco system. Often this was called out as an optional siding package on the building plans and might vary based on the home in the tract development or the orientation of the building on site.

Secondary Wall Systems.

One hundred percent of the homes in the plan review data set and field inspected data set had an attached garage and therefore included an insulated wall between the house and the garage. The secondary wall systems found in the study consisted of the following construction practice:

- Framing Type –all walls are 16" o.c. Wood studs
- Average Area
    - Field Inspected Data - 257.76 Gross Square Feet
    - Plan Reviewed (Total Population) – 294.99 Square Feet
- Weighted Average of Insulation R-Value
    - Plan Check – 13.8
    - Field Inspection – 13.8
    - Plan-reviewed (Total Population) – 12.7

The insulation placement was always between the framed cavities. There was no difference between the average insulation R-value between the Plan Check data and Field Inspection data. Compared to the total number of homes that were plan-reviewed, the field data was slightly higher.

Tertiary Wall Systems.

Five of the homes that were both plan reviewed and field inspected included attic kneewalls as defined above. The tertiary wall systems found in the study consisted of the following construction practice:

- Framing Type –all walls wood trusses
- Average Area
    - Field Inspected Data - 230 Gross Square Feet
    - Plan Reviewed (Total Population) – 137.17
- Weighted Average of Insulation R-Value
    - Plan Check – 13.0
    - Field Inspection – 15.0
    - Plan-reviewed (Total Population) – 13.1

The insulation placement was always between the framed cavities. The slight difference between the average insulation R-value between the Plan Check data and Field Inspection data can be attributed to higher R-values called out on the building plans versus what was found out in the field. The wall R-value for the total population of plan reviewed data was consistent with what was found in the field.

Section 5.2.5 Roof Information. Data on roof systems was collected to determine the average roof area and insulation R-value. Typically, the primary roof system was considered the system that was predominantly used in the home e.g. a vented attic. If a home used both standard truss systems for a flat ceiling and then a scissor truss system for a vaulted ceiling, these were combined into one roof system as they both include a vented attic. For Southern Nevada all homes included in the sample consisted of:

- Framing Type –All Wood Joist Rafter Truss Systems
- Average Area
    - Field Inspected Data – 1678 Square Feet

  - Plan Reviewed (Total Population) - 1795
- Weighted Average of Insulation R-Value
  - Plan Check – 27.2
  - Field Inspection – 30.0
  - Plan Reviewed (Total Population) – 29.9

Based on the data collected in the field and that shown on the building plans the standard insulation level is an R-30.

Section 5.2.6 Window/Skylight Information. Information on window type, glazing efficiency and glazing area was collected during both the Plan Check and Field Inspection portion of the study. As reported earlier in the study the majority of the plan reviews did not include information on window type. Collecting information on glazing unit type and U-factor was left to the field collection team. For Southern Nevada, the Solar Heat Gain Coefficient was also collected during the field collection process, as this data was not included on the plans. Both the U-factor and SHGC values were collected from the NFRC labels. If there were no labels on the windows, the data collection form allowed a space for collecting the window frame type and number of panes. Frequently, information on both the glazing U-factor and window type was collected.

Primary Window Type.

The primary window type found in the field was aluminum double pane. The primary window type was defined as the predominant glazing type found in each of the houses. The primary window type was an operable window. The primary windows had the following characteristics:

- Average Square Feet Glazing Area
  - Plan Check - 245
  - Field inspection - 227
  - Plan Check (Total Population) – 246.02
- Weighted Average U- Factor
  - Plan Check - .71
  - Field Inspection - .74
  - Plan Check (Total Population) – .79
- Weighted average SHCG Field Inspection - .60

The area for the homes that received both a plan review and field inspection had a greater area of glazing identified on the building plans than found in the field. As with Northern Nevada, the U-factor of the glazing found in the field was lower than that called out on the plans. The SHGC value found on the window units in the field had an average of .60. This data was collected because the 2000 IECC requires a SHGC value of .40 for all residential buildings in climate zones less than 3,500 Heating Degree Days (HDD). This is only a requirement under Chapter 5 and 6 of the IECC and with the use of the US DOE MEC*check* software. Chapter 4 allows this to be traded-off.

Secondary Window Type.

Eleven of the 12 houses within the sample included secondary windows that either were fixed or glass block. The secondary window characteristics were as follows:

- Average Square Feet Glazing Area
  - Plan Check - 81
  - Field inspection - 50
  - Plan Check (total population) – 81.68
- Weighted Average U- Factor

  - Plan Check .53
  - Field inspection .61
  - Plan Check (total population) - .70
    - Default U-factor used of .50 was used in 1, or .07% of homes with secondary windows

- Weighted Average SHGC (Field Inspected Data) - .49

In general, the window area found on site was less than what was shown on the plans by an average of 30 square feet. The total area found on the building plans for the smaller population of buildings is consistent with the total population of Plan Check data.

Section 5.2.7 Door Information. The type and area of doors either located in the exterior wall, or in the wall between the house and garage, was recorded during the plan check process and the field inspection process consistent with the process used in Northern Nevada. Only the data recorded in the field was included in this report as there was typically no information included on the building plans for exterior doors. Solid core, self-closing garage doors were typically called out on the building plans.

Main Entrance Doors.

Table 5.2.7(1) includes information on the main entrance door to the house. The primary door type in Southern Nevada was a steel foam core door (53.84%). The average area for the entrance doors was 26.46 square feet. A typical 3-foot wide entrance door is approximately 20 square feet. Several of the doors found on the larger homes were 8 foot in height or included double 3 foot X 7 foot double doors. The weighted average U-factor for the entrance doors was 0.44.

Main Entrance Door - Type	
Steel foam core	53.84%
Steel hollow	38.46%
Solid core flush	7.70%

Table 5.2.7(1)

Garage/House Door.

Table 5.1.7(2) includes information on the door to the garage. The typical door type in Southern Nevada was a solid core flush door (100%). Solid core doors are typically installed to meet the building code requirements. The average area for the entrance doors was 18 square feet. The weighted average U-factor for the entrance doors was 0.36.

Other Exterior Door.

Two of the homes included a second door leading from the interior to the outside through the exterior wall. Both of the doors were glass. The average door size was 49 square feet. The average U-factor was 0.85.

Section 5.2.8 Duct Information - Field Inspection Only Data. Information concerning the duct system was collected during the field inspection process. Data was collected for both the return and duct systems.

Return Duct System.

The location of the return ducts, the type of duct material type of sealant and duct insulation R-value was recorded during the field inspection portion of the study. All of the return systems were located in the attic because all of the floor systems were slab-on-grade. One hundred percent of the return systems were flexible duct systems.

As with Northern Nevada an important element of the study looked at the method of duct sealing that was used on the return duct systems. Table 5.2.8(1) provides the frequency of each type of duct sealant method that was found in the field. The use of UL 181 listed and labeled duct tape was found on 76.92% of the systems. Mastic was used on 69.23% of the sheet metal portions of the return duct systems. In contrast to Northern Nevada, there were no cases of unlisted and labeled duct tape used on the duct systems that were inspected.

Sealant Use	
Return Duct Sealant UL181 Tape	76.92%
Return Duct Sealant Mastic	69.23%
Return Duct Sealant Mastic+Tape	0%
Return Duct Sealant Duct Tape	0%
Return Duct Sealant Zip Ties	38.46%
Return Duct Sealant Screws	0%

Table 5.2.8(1)

The insulation found on all flex type ducts had an R-vale rating of 4.2.

Supply Duct Systems.

The location of the supply ducts, the type of duct material type of sealant and duct insulation R-value was recorded during the field inspection portion of the study. Table 5.1.8(2) shows the distribution of duct locations. All of the supply ducts were located in the attic. This corresponds to all of the structures having slab-on-grade foundations. The primary duct type was flexible duct.

As with the method of duct sealing for the return ducts, the sealant method for the supply ducts was also recorded. Table 5.2.8(3) provides the frequency of each type of duct sealant method that was found in the field. The use of listed and labeled tapes (UL 181 Tape) was found on 76.92% of the systems. The use of mastic was found on 69.23% of the systems often in combination with UL tapes. As with the return duct systems, there were no reported cases of unapproved duct tape use.

Sealant Use	
Supply Duct Sealant UL181 Tape	76.92%
Supply Duct Sealant Mastic	69.23%
Supply Duct Sealant Mastic+Tape	0%
Supply Duct Sealant Duct Tape	0%
Supply Duct Sealant Zip Ties	38.46%
Supply Duct Sealant Screws	0%

Table 5.2.8(2)

All of the flexible type ducts had an insulation R-value of 4.2.

Section 5.2.9 Mechanical System. This section reports primarily on data found during the field inspection portion of the study because the plans and documentation submitted to the jurisdictions typically assume a minimum of 78% AFUE unless otherwise noted. All of the heating systems in the homes that were surveyed used gas furnaces for the heating source. The average AFUE for the gas furnaces surveyed was 80. This compares with an average of the total population of plan-reviewed houses of 78.82%.

Cooling Efficiency.

One hundred percent of the structures had air-cooled air conditioning. The average SEER for the systems was 10. If the SEER of the system could not be determined on-site the system was assigned a minimum SEER of 10. This occurred on only one of the homes.

Section 5.2.10 Air Leakage Testing. Consistent with Northern Nevada, each of the field inspected homes was blower door tested to determine the Natural Air Changes Per Hour (nACH) at 50 Pascals. A Pressure Pan Duct Leakage Test was also conducted in each of the homes.

Blower Door Testing.

The average Natural Air Changes Per Hour for each of the homes tested was .23 nACH. As a comparison, the 1995 Model Energy Code assumes a nACH of .51 for the standard or "code house". The testing was conducted in homes that were typically at, or near, the final inspection. The sheetrock had been installed, and the weatherstripping had been installed around all of the windows and doors located in the exterior walls and those leading to the garage. If the weatherstripping had not been installed on the doors during the time that the buildings were tested, tape was used to seal up the leakage points. Table 5.2.10(1) shows a frequency distribution of the homes tested and the calculated nACH. The majority of the homes (73%) tested less than .29 nACH range.

Natural Air Changes Hour (nACH) Results – 50 pascals	
nACH Ranges	# Of Homes
< .20	1
.20 - .29	7
.30 - .39	3
Total Homes	11

Table 5.2.10(1)

Average Pan Pressure.

A pressure pan test was conducted at each of the supply and return registers in each field inspected sample. As explained in Section 5.1.10 the test was conducted to determine the relative leakiness of the duct system. In Southern Nevada, the average pressure pan test for the supply ducts was .31 Pascals. For return ducts, the average pressure difference was 2.27 Pascals.

Table 5.2.10(2) shows a frequency distribution based on the pressure pan readings for both supply and return ductwork. For supply ducts, a pressure difference less than .20 was the predominate reading.

Eighty two percent of the supply duct systems had a pressure difference less than .50 Pascals, which indicates a very small duct leakage rate evidence of a well-sealed, quality duct installation. Return ducts were predominantly between a pressure difference of between 1.0 – 1.9 pascals which indicates small to moderate duct leakage (please refer to Table 5.1.10.3 for a comparison). The return duct systems tested in Southern Nevada had much less leakage than those tested in Northern Nevada which can possibly be attributed to better duct sealing methods and a limited use of framed cavities to act as part of the return air system. One of the systems did have a return duct leakage of 13.4 Pascals, which indicated large duct leakage. While the field inspected sample for Southern Nevada was a small percentage of the total population, the pressure pan results indicate that the ducts are sealed better than those in Northern Nevada. This is consistent with the duct sealant methods used in Southern Nevada.

Condition of Duct System	Supply	Return
<.20	3	0
.20 - .29	2	1
.30 – .39	2	1
.40 - .49	2	0
.50 - .59	2	0
1.0 - 1.9	0	6
2.0 – 2.9	0	1
3+	0	1

Table 5.2.10(2)

Section 5.3 Las Vegas Metro, Energy Star and Engineered For Life

The analysis that follows for Las Vegas Metro, Energy Star and Engineered for Life/Environment for Living is based on a sample of homes assessed by Woods and Associates in conjunction with the firm's Energy Star and Engineered for Life program compliance assessment work in the Las Vegas region. Woods and Associates is involved in both the plan review and field inspection phases of construction of these homes, and provided this study with field inspection data for the following sample:

- Plan Check – 0
- Field Inspection – 48

Section 5.3.1 Determining Increases in Efficiency to Demonstrate Compliance with Different Code editions. As stated earlier, in Section 5.1.2, one of goals of the study was to determine the incremental increases in level of efficiency required to bring a noncompliant home into compliance with the particular code edition. Typical upgrades in efficiency were identified for the Las Vegas Region that could be used to bring up the level of compliance, when necessary. These were based on regional construction practices and cost. To ensure consistency the upgrades were added in order of expected cost until compliance was demonstrated for a particular home. For example, the first upgrade was to increase the efficiency of the windows by modeling the buildings with a glazing U-factor of 0.60. If the building did not comply, or if the glazing U-factor was already at 0.60, the next upgrade was to increase the wall insulation R-value to an R-13. Air conditioning efficiency was increased next, going to a SEER of 12. The final upgrade was to go to an R-38 ceiling insulation. No changes were made to the window area, assembly areas or volume of the building.

The goal was to gain compliance for the structure, which could be defined as a zero (0) percent compliance margin or better. For example if adding the feature raised the margin from a –5% worse than code to a +2% better than code the analysis ended and the results recorded. No attempt was made to "optimize" the model to back the compliance margin back to minimal code compliance or zero. For the Las Vegas Metro Region the following upgrades were used:

Upgrade One – Window U-factor to U 0.60

Upgrade Two – Wall R-value to R-13

Upgrade Three – Air Conditioning Efficiency to a SEER of 12

Upgrade Four –Ceiling Insulation to R-38

			Improvements Needed to Comply (Listed in Order of Upgrades)			
Average Compliance Rate			Windows to .60	Wall to R-13	AC SEER to 12	Ceiling to R-38
	Plan Check	Field Inspection				
1992 MEC	N/A	10%	5	0	5	2
1993 MEC	N/A	10%	5	0	5	2
1995 MEC	N/A	7%	11	0	8	3
1998 IECC	N/A	7%	11	0	8	3
2000 IECC	N/A	7%	11	0	8	3

Table 5.3.1 Efficiency Upgrades to Demonstrate Compliance

Table 5.3.1 displays the conservation feature upgrades required to demonstrate compliance with each of the code editions for the population of homes. The table also displays the total number of occurrences that each conservation feature was added to a home to show compliance with a particular year of the code. For example, 15 homes did not comply with the 1995 MEC. Of these homes, 11 homes were required to increase window efficiency to .60. None of the homes required the next upgrade of wall insulation to R-13. Eight of the homes were required to increase the air conditioning SEER to 12. As the next step, three of the noncompliant homes were required to increase the ceiling insulation to .38; only three of the home was required to make this modification.

The upgrade packages represented in this report represent on one option selected to demonstrate compliance with the various code editions. Based on the compliance approach used, the packages may differ as the documentation author optimizes the compliance package based on the building configuration.

This study pointed out the differences between performance-based compliance based on Chapter 4 of the MEC/IECC and a U-value X Area Trade-off approach used in the MEC*check* Code Compliance software. All of the buildings that qualified under an Energy Star type of program used a Chapter 4 analysis tool to demonstrate compliance. This tool allowed infiltration trade-offs and took advantage of duct leakage reductions to offset lower thermal efficiency in the building envelope. This population also took advantage of lower Solar Heat Gain Coefficient glazing. MEC*check* requires the building to demonstrate compliance by only considering the insulation and glazing efficiencies. This will typically require higher insulation levels and better windows to demonstrate compliance versus using a Chapter 4 approach.

Summary of Findings – Las Vegas Metro, Energy Star and Engineered for Life
Figure 5.3
Based on Field Inspection – Sample Size of 48

Primary Roof: All Wood Rafter/Joist Truss – 100%

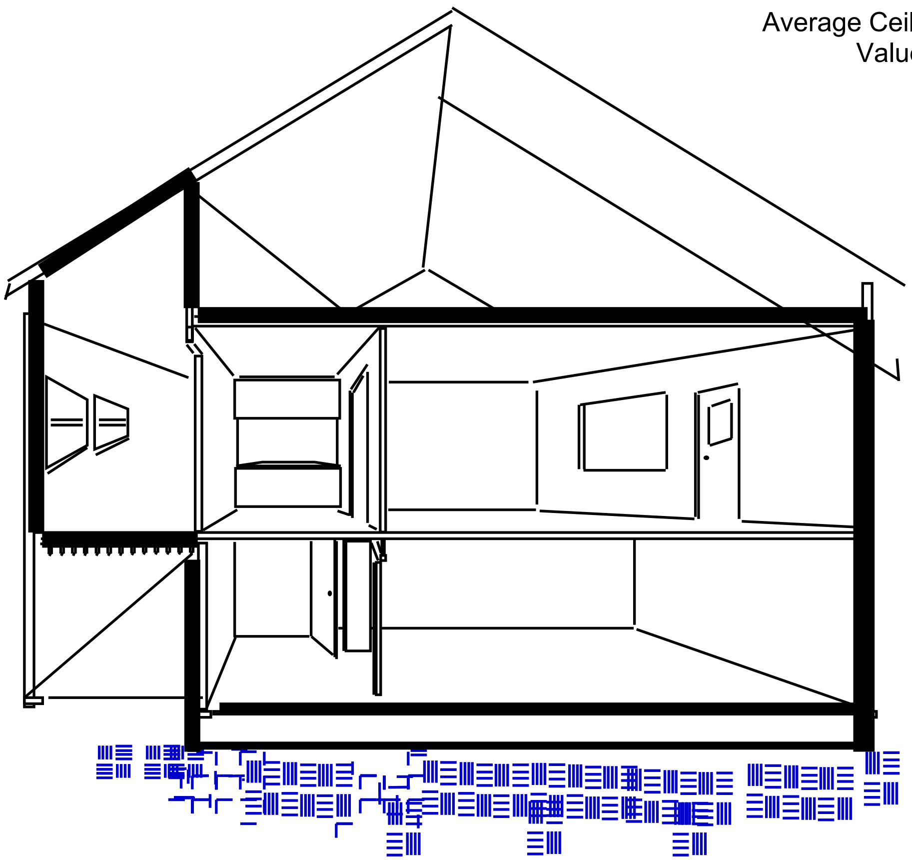
Average Ceiling Insulation R-Value – 29.11

Average Glazing Square Footage-391

Typical Glazing – Metal Double Pane 81%

Average Glazing:Wall Area Ratio-17%

Typical Entrance Door – Unlabled 100%



Primary Walls: Wood Frame, 16” o.c. – 100%

Average Wall Insulation R-Value – 16.54

Typical Heating System- Gas Heating 100%
Average AFUE- 81%

Typical Cooling System- Air Cooled Air 88%
Average SEER- 10.85

Foundation: Slab – 100%

Average Insulation R-Value – 0

Average Square Footage: 2017

Average MecCheck Results

1992 MEC 10%
1993 MEC 9%
1995 MEC 7%
1998 IECC 7%
2000 IECC 7%

Section 5.3.2. Foundation System. The typical primary foundation for homes in the Las Vegas region is slab on grade. The foundations are not typically insulated, as was found in the study sample.

- Foundation System
  - Slab – 100%
  - Insulation R-Value: 0
  - Average linear feet - 187

The average linear feet of the primary foundations was 187 feet.

Approximately 33% (16) of the homes surveyed had more than one foundation type. Of those homes that included a secondary foundation type 100% were categorized as a "crawlspace insulated floor". These were floors over a garage in a two-story house with an average weighted R-value of 16.5.

- Secondary Foundation Information
  - 16 Field Inspected Homes had secondary foundations.
  - Crawlspace Insulated Floor (Floor over garage) – 100%
  - Insulation R-value, weighted average – 16.5
  - Average area – 306 square feet

Section 5.3.3 Exterior Wall Information. Three types of wall systems were documented within the study. Exterior walls were considered walls between the conditioned space and the outdoors. Secondary wall systems were defined as walls between the conditioned space and an attached garage. Tertiary walls were defined as the wall between the conditioned space and the ventilated attic or more commonly referred to as an attic kneewall. This condition occurred in homes with vaulted ceilings.

Exterior wall Systems.

All of the exterior wall systems found in the field inspected homes in Southern Nevada consisted of the following construction practice:

- Framing Type –Wood studs 16" on-center spacing
- Average Area
  - Field Inspected - 1910 Gross Square Feet
- Weighted Average of Insulation R-Value
  - Field Inspection – 16.5

The insulation placement information is not available for this sample set.

Secondary Wall Systems.

One hundred percent of the homes in the plan review data set and field inspected data set had an attached garage and therefore included an insulated wall between the house and the garage. The secondary wall systems found in the study consisted of the following construction practice:

- Framing Type –all walls are 16" o.c. Wood studs
- Average Area
  - Field Inspected Data - 286 Gross Square Feet
- Weighted Average of Insulation R-Value
  - Field Inspection – 12.6

Tertiary Wall Systems.

One of the homes included attic kneewalls as defined above. The tertiary wall systems found in the study consisted of the following construction practice:

- Framing Type –all walls wood trusses
- Average Area
    - Field Inspected Data - 91 Gross Square Feet
- Weighted Average of Insulation R-Value
    - Field Inspection - 19

Section 5.3.4 Roof Information. Data on roof systems was collected to determine the average roof area and insulation R-value. Typically, the primary roof system was considered the system that was predominantly used in the home e.g. a vented attic. If a home used both standard truss systems for a flat ceiling and then a scissor truss system for a vaulted ceiling, these were combined into one roof system as they both include a vented attic. For Southern Nevada all homes included in the sample consisted of:

- Framing Type –All Wood Joist Rafter Truss Systems
- Average Area – 1838 Square Feet
- Weighted Average of Insulation R-Value – 29.8

Based on the data collected in the field, and that shown on the building plans, the standard insulation level is an R-30.

Section 5.3.5 Window/Skylight Information. Information on both the U-factor and SHGC values were provided by Woods and Associates for this sample portion of the study, based on their data for each structure. Data provided by Woods and Associates was initially developed for a different purpose and did not differentiate between primary and secondary windows.

Primary Window Type.

The primary window type found in the field was aluminum double pane. The primary window type was defined as the predominant glazing type found in each of the houses. The primary window type was an operable window. The primary windows had the following characteristics:

Primary Window Type	
Metal	81.23%
Vinyl	2.10%
Vinyl Low E	16.67%

Table 5.3.5 Primary Window Type Distribution

- Average Square Feet Glazing Area– 389.9
- Weighted Average U- Factor – Plan Check - .62
- Weighted Average SHCG - .42

As noted above, the SHGC value found on the window units in the field had an average of .42. This data was collected because the 2000 IECC requires a SHGC value of .40 for all residential buildings in climate zones less than 3,500 Heating Degree Days (HDD). This is only a requirement under Chapter 5 and 6 of the IECC and with the use of the US DOE MEC*check* software. Chapter 4 allows this to be traded-off.

Section 5.3.6 Door Information. In this sample portion of the study, two types of doors were identified – primary exterior wall doors, and secondary house/garage doors. The area of the door was noted, however the type (e.g. solid core) of door was not available. In all MECcheck calculations, a default U-factor of .33 was used.

Main Entrance Doors.

The average area exterior door was 26 square feet. A typical 3-foot wide entrance door is approximately 20 square feet. Several homes had larger doors, and multiple doors, which effected the square footage of exterior door.

Garage/House Door.

Solid core doors are typically installed to meet the building code requirements. The average area for the garage/house door was 18.47 square feet.

Section 5.3.7 Duct Information - Field Inspection Only Data. Information concerning the duct system was collected during the field inspection process. Data was collected for both the return and duct systems.

Return Duct System.

All of the return systems were located in the attic because all of the floor systems were slab-on-grade. Ninety-eight percent of the return systems were flexible duct systems. The typical insulation found on all flex type ducts had an R-value rating of 4.2, although some were insulated to an R-value of 6.

Supply Duct Systems.

All of the supply ducts were located in the attic. This corresponds to all of the structures having slab-on-grade foundations. The primary duct type was flexible duct. The typical insulation found on all flex type ducts had an R-value rating of 4.2, although some were insulated to an R-value of 6.

Section 5.3.8. Mechanical System. All of the heating systems in the homes that were surveyed used gas furnaces for the heating source. The average AFUE for the gas furnaces surveyed was 80.63. This compares with an average of the total population of plan-reviewed houses of 78.82% in the Southern Nevada section of this study.

Cooling Efficiency.

Eighty-eight percent of the structures had air-cooled air conditioning. The average SEER for the systems was 10.85. Woods and Associates was able to provide SEER data for all structures in this portion of the study and a default SEER was not necessary.

Section 5.3.9 Air Leakage Testing. Consistent with Northern Nevada, each of the field inspected homes was blower door tested to determine the Natural Air Changes Per Hour (nACH) at 50 Pascals.

Blower Door Testing.

The average Natural Air Changes Per Hour for each of the homes tested was .24 nACH. As a comparison, the 1995 Model Energy Code assumes a nACH of .51 for the standard or “code house”. The testing was conducted in homes that were typically at, or near, the final inspection. The sheetrock had been installed, and the weatherstripping had been installed around all of the windows and doors located in the exterior walls and those leading to the garage. If the weatherstripping had not been installed on the doors during the time that the buildings were tested, tape was used to seal up the leakage points. Table 5.3.9(1) shows a frequency distribution of the homes tested and the calculated nACH. The majority of the homes (79%) tested less than .29 nACH range and 38% tested less than .20 nACH.

Natural Air Changes Hour (nACH) Results – 50 pascals	
nACH Ranges	# Of Homes
< .20	18
.20 - .29	20
.30 - .39	7
.40 - .49	2
.50 - .59	1
Total Homes	48

Table 5.3.9(1)

Average Pan Pressure.

Pressure pan test results were not available for this sample set.

Section 5.4 Las Vegas Metro, Standard Construction

The analysis that follows for Las Vegas Metro, Standard Construction is based on a sample of homes assessed by Woods and Associates. Woods and Associates is involved in both the plan review and field inspection phases of construction of these homes, and provided this study with field inspection data for the following sample:

- Plan Check – 0
- Field Inspection – 52

Section 5.4.1 Determining Increases in Efficiency to Demonstrate Compliance with Different Code Editions. As stated earlier, in Section 5.1.2, one of goals of the study was to determine the incremental increases in level of efficiency required to bring a noncompliant home into compliance with the particular code edition. Typical upgrades in efficiency were identified for the Las Vegas Region that could be used to bring up the level of compliance, when necessary. These were based on regional construction practices and cost. To ensure consistency the upgrades were added in order until compliance was demonstrated for a particular home. For example, the first upgrade was to increase the efficiency of the windows by modeling the buildings with a glazing U-factor of 0.60. If the building did not comply, or if the glazing U-factor was already at 0.60, the next upgrade was to increase the wall insulation R-value to an R-13. Air conditioning efficiency was increased next, going to a SEER of 12. The final upgrade was to go to an R-38 ceiling insulation.

No changes were made to the window area, assembly areas or volume of the building

The goal was to gain compliance for the structure, which could be defined as a zero (0) percent compliance margin or better. For example if adding the feature raised the margin from a –5% worse than code to a +2% better than code the analysis ended and the results recorded. No attempt was made to “optimize” the model to back the compliance margin back to minimal code compliance or zero. For the Las Vegas Metro Region the following upgrades were used:

Upgrade One – Window U-factor to U 0.60

Upgrade Two – Wall R-value to R-13

Upgrade Three – Air Conditioning Efficiency to a SEER of 12

Upgrade Four –Ceiling Insulation to R-38

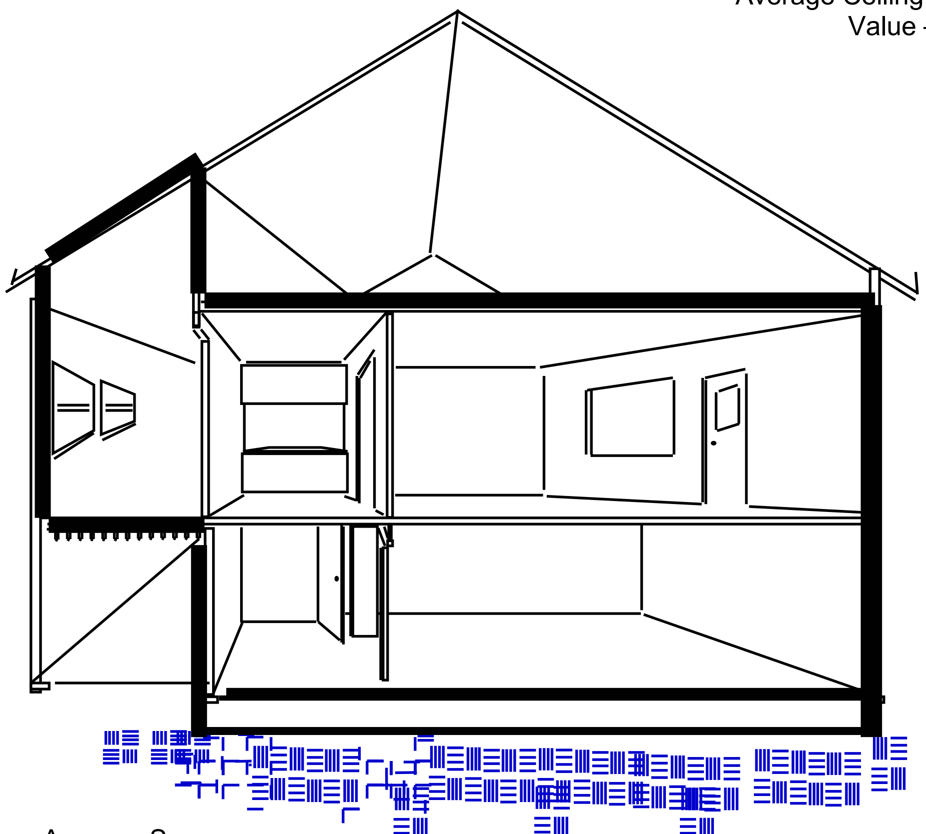
			Improvements Needed to Comply			
Average Compliance Rate			Windows to .60	Wall to R-13	AC SEER to 12	Ceiling to R-38
	Plan Check	Field Inspection				
1992 MEC	N/A	6%	10	1	2	0
1993 MEC	N/A	5%	11	1	2	0
1995 MEC	N/A	4%	13	1	3	0
1998 IECC	N/A	4%	13	1	3	0
2000 IECC	N/A	4%	13	1	3	0

Table 5.4.1 Efficiency Upgrades to Demonstrate Compliance

Table 5.4.1 displays the conservation feature upgrades required to demonstrate compliance with each of the code editions for the population of homes. The table also displays the total number of occurrences that each conservation feature was added to a home to show compliance with a particular year of the code. For example, 14 homes did not comply with the 1995 MEC. Of these homes, 13 homes were required to increase window efficiency to .60. One of the homes required the next upgrade of wall insulation to R-13. Three of the homes were required to increase the air conditioning SEER to 12

.

Summary of Findings – Las Vegas Metro, Standard Construction
Figure 5.4
Based on Field Inspection – Sample Size 52



Average MecCheck Results

1992 MEC 6%
1993 MEC 5%
1995 MEC 4%
1998 IECC 4%
2000 IECC 4%

Section 5.4.2. Foundation System. The typical primary foundation for homes in the Las Vegas region is slab on grade. The foundations are not typically insulated, as was found in the study sample.

- Foundation System
    - Slab – 100%
    - Insulation R-Value: 0
    - Average linear feet - 195

The average linear feet of the primary foundations was 195 feet.

Approximately 36% (19) of the homes surveyed had more than one foundation type. Of those homes that included a secondary foundation type 100% were categorized as a “crawlspace insulated floor”. These were floors over a garage in a two-story house with an average weighted R-value of 16.9.

- Secondary Foundation Information
    - 19 Field Inspected Homes had secondary foundations.
    - Crawlspace Insulated Floor (Floor over garage) – 100%
    - Insulation R-value, weighted average – 16.9
    - Average area – 334 square feet

Section 5.4.3 Exterior Wall Information. Three types of wall systems were documented within the study. Exterior walls were considered walls between the conditioned space and the outdoors. Secondary wall systems were defined as walls between the conditioned space and an attached garage. Tertiary walls were defined as the wall between the conditioned space and the ventilated attic or more commonly referred to as an attic kneewall. This condition occurred in homes with vaulted ceilings.

Exterior wall Systems.

All of the exterior wall systems found in the field inspected homes in Southern Nevada consisted of the following construction practice:

- Framing Type –Wood studs 16” on-center spacing
- Average Area- 2074 Gross Square Feet
- Weighted Average of Insulation R-Value – 16

The insulation placement information is not available for this sample set.

Secondary Wall Systems.

One hundred percent of the homes in the plan review data set and field inspected data set had an attached garage and therefore included an insulated wall between the house and the garage. The secondary wall systems found in the study consisted of the following construction practice:

- Framing Type –all walls are 16” o.c. Wood studs
- Average Area – 298 Gross Square Feet
- Weighted Average of Insulation R-Value – 11.6

Tertiary Wall Systems.

None of the homes in this sample set had tertiary wall systems

Section 5.3.4 Roof Information. Data on roof systems was collected to determine the average roof area and insulation R-value. Typically, the primary roof system was considered the system that was predominantly used in the home, e.g. a vented attic. If a home used both standard truss systems for a flat ceiling and then a scissor truss system for a vaulted ceiling, these were combined into one roof system as they both include a vented attic. For the Las Vegas Metro, Standard Construction, all homes included in the sample consisted of:

- Framing Type –All Wood Joist Rafter Truss Systems
- Average Area – 1889 Square Feet
- Weighted Average of Insulation R-Value – 30

Based on the data collected in the field, the standard insulation level is an R-30.

Section 5.4.5 Window/Skylight Information. Information on both the U-factor and SHGC values were provided by Woods and Associates for this sample portion of the study, based on their data for each structure. Data provided by Woods and Associates was initially developed for a different purpose and did not differentiate between primary and secondary windows.

Primary Window Type.

The primary window type found in the field was aluminum double pane. The primary window type was defined as the predominant glazing type found in each of the houses. The primary window type was an operable window. The primary windows had the following characteristics:

Primary Window Type	
Metal	96%
Unlabeled	4%

Table 5.4.5 Primary Window Type Distribution

- Average Square Feet Glazing Area– 381
- Weighted Average U- Factor – .70
- Weighted Average SHCG - .58

As noted above, the SHGC value found on the window units in the field had an average of .42. This data was collected because the 2000 IECC requires a SHGC value of .40 for all residential buildings in climate zones less than 3,500 Heating Degree Days (HDD). This is only a requirement under Chapter 5 and 6 of the IECC and with the use of the US DOE MEC*check* software. Chapter 4 allows this to be traded-off.

Section 5.4.6 Door Information. In this sample portion of the study, two types of doors were identified – primary exterior wall doors, and secondary house/garage doors. The area of the door was noted, however the type (e.g. solid core) of door was not available. In all MEC*check* calculations, a default U-factor of .33 was used.

Main Entrance Doors.

The average area of exterior doors was 27 square feet. A typical 3-foot wide entrance door is approximately 20 square feet. Several homes had larger doors, and multiple doors, which effected the square footage of exterior door.

Garage/House Door.

Solid core doors are typically installed to meet the building code requirements. The average area for the garage/house door was 19.43 square feet.

Section 5.4.7 Duct Information - Field Inspection Only Data. Information concerning the duct system was collected during the field inspection process. Data was collected for both the return and duct systems.

Return Duct System.

All of the return systems were located in the attic because all of the floor systems were slab-on-grade. Ninety-eight percent of the return systems were flexible duct systems. The typical insulation found on all flex type ducts had an R-value rating of 4.2.

Supply Duct Systems.

All of the supply ducts were located in the attic. This corresponds to all of the structures having slab-on-grade foundations. The primary duct type was flexible duct. The typical insulation found on all flex type ducts had an R-value rating of 4.2.

Section 5.4.8. Mechanical System. All of the heating systems in the homes that were surveyed used gas furnaces for the heating source. The average AFUE for the gas furnaces surveyed was 80. This compares with an average of the total population of plan-reviewed houses of 78.82% in the Southern Nevada section of this study.

Additionally, 31% of the structures had secondary gas furnace heating systems, with an average AFUE of 79.

Cooling Efficiency.

Eighty-eight percent of the structures had air-cooled air conditioning. The average SEER for the systems was 10.19. Woods and Associates was able to provide SEER data for all structures in this portion of the study and a default SEER was not necessary.

Additionally, 60% of the structures had a secondary cooling system with an average SEER of 10.25

Section 5.3.9 Air Leakage Testing. Consistent with Northern Nevada, each of the field inspected homes was blower door tested to determine the Natural Air Changes Per Hour (nACH) at 50 Pascals. A Pressure Pan Duct Leakage Test was also conducted in each of the homes.

Blower Door Testing.

The average Natural Air Changes Per Hour for each of the homes tested was .23 nACH. As a comparison, the 1995 Model Energy Code assumes a nACH of .51 for the standard or “code house”. The testing was conducted in homes that were typically at, or near, the final inspection. The sheetrock had been installed, and the weatherstripping had been installed around all of the windows and doors located in the exterior walls and those leading to the garage. If the weatherstripping had not been installed on the doors during the time that the buildings were tested, tape was used to seal up the leakage points. Table 5.3.9(1) shows a frequency distribution of the homes tested and the calculated nACH. The majority of the homes (77%) tested less than .29 nACH range with 13% testing less than .20 nACH. This is consistent with the testing done on the original sample for Southern Nevada.

Natural Air Changes Hour (nACH) Results – 50 pascals	
nACH Ranges	# Of Homes
< .20	7
.20 - .29	33
.30 - .39	12
Total Homes	52

Table 5.3.9(1)

Average Pan Pressure.

Pressure pan test results were not available for this sample set.

SECTION 6.0 ISSUES AND RECOMMENDATIONS

Section 6.1 Selection of Project Sample

As stated in the study, gaining cooperation with the builders was difficult in both Northern and Southern Nevada. The study was successful in gaining access to the job sites in Northern Nevada but a portion of the original sample was replaced. The field data collection process in Southern Nevada was unsuccessful requiring the project partners to change course in an attempt to meet the goals of the grant. The following course of action is recommended with respect to completion of similar studies:

Recommendations:

Gain cooperation from the local homebuilder associations prior to the start of the study so that they can notify their membership. The homebuilder groups and their membership must be comfortable that the results of the study will remain anonymous and that this study is for general, existing benchmark purposes only and not an audit of the builder's performance.

Gain cooperation from the building official association(s) to ensure that they are active participants in the study. This can go as far as allowing the jurisdictions to self-select to participate in the study.

Request that the jurisdictions contact the builders prior to selecting their project for the study to ensure that the builder will cooperate. In addition, having the builders sign a "Builder Participation Form" prior to starting the data collection process will ensure that the builder is aware of the project and is willing to participate.

Select homes located in tract developments versus custom homes. This will allow the flexibility of going into a track and looking at the buildings in various stages of construction. This will also allow field inspection to be conducted on the model if the selected buildings are not finished.

Section 6.2 Data Collection Staff

Selecting staff to collect building data that are knowledgeable about the builders in the region and that have experience in both plan review and field inspection are critical to the success of study. Using locally based data collection staff will provide the needed flexibility to collect on-site data from one or two houses at a time without needing to travel in and out of the region or state on a scheduled basis. Also, selecting staff that require little to no training in reviewing plans and collecting information in the field will reduce the amount of time that the building official and builder will need to allow for the study. For future studies the following course of action is recommended:

Recommendations:

Utilize trained home energy raters and/or home inspection staff located in the region that are trained in both plan review and field inspection and that can operate a blower door effectively. This will limit the quantity of time that the staff will need to spend at the jurisdiction office and on the construction site. Those involved in these professions will typically also have contact with local builders and potentially builder associations.

Section 6.3 Training of Data Collection Staff

It is important to train the data collection staff to complete the data collection forms using consistent process and terminology. This will remove the guesswork during the data analysis process, especially if the data analysis is conducted by another individual. For future studies the following course of action is recommended:

Recommendation:

Conduct training for the data collection staff for both plan review and field collection. The training materials that were utilized for this study are included in this report and can be used as a basis for the training. One day of training in the classroom is recommended along with a half-day in the field to cover blower door test field data collection protocol.

Section 6.4 Scheduling of Plan Review and Field Data Collection

The field collection portion of the study should closely follow plan review to ensure that the homes that were selected are not occupied once the team is ready to go into the field. This occurred in Northern Nevada and was preventable if the team had scheduled the field collection directly after reviewing the plans. For future studies the following course of action is recommended:

Recommendations:

Ensure that the builder is still building the model (if a tract development) that was selected for the study. The jurisdiction may not know that a particular model has been discontinued. When in doubt, call the builder directly before selecting the plan set.

Contact the builder within one-week of finishing the plan review portion of the project to start scheduling field inspections. If two to three homes are selected from the same development, try to schedule to visit all of them on the same visit. It is important to work around the builder's schedule as their participation is voluntary and should be respected accordingly. This may mean getting to the site prior to, or after, the construction trade crews or to the models prior to them opening.

Try not to select buildings in the sample that will not be finished after 3 months. It is best to select buildings that either are close to being completed or will be done in one-to two-months. Selecting buildings that will take longer to finish will lengthen the study and there will be a chance that the home may not be built.

Section 6.5 Data Collection and Analysis Tools

The data collection and analysis tools used in the study were developed in tandem with the project goals. Based on the goals, an analysis tool was identified which would produce the most useful information. Project analysts determined that Microsoft Access would be the most useful database, it would be used in tandem with Microsoft Excel and the DOE MECcheck tool to provide analysis of the data collected. The next step was to develop a data collection tool that would support the effort. It was decided that a data collection worksheet could best be developed in Microsoft Excel, which provided for an option of electronic data collection. The data collection worksheet was designed to support the data collection team in collecting the information needed for MECcheck compliance analysis, and collection of all additional data needed in the plan review and field inspection steps of the study. For future studies the following course of action is recommended:

Recommendations:

Determine the goals of the project before selecting the data analysis tool. The tool should meet the needs of the study but should also allow for a data collection tool that can be completed easily and quickly by the data collection team.

The data collection form should be developed based on the data analysis tool. MEC*check* met both the goals of the project and the data collection form was easily developed based on the inputs into the software.

Allow the data collection team to participate in the development of the form. It is critical that the team in the field be comfortable in using the form and is allowed to give comments on its design. This will go far in ensuring that they will collect the correct information.

Decide what type of information that must be collected during the study and what can be ignored. Collecting too much information can be more of an obstruction than the data is worth especially if the data will not be used in the final reporting for the project. The data collection team will only have a limited quantity of time to collect data due to time and budget constraints so limiting the data collected will be important.

Section 6.6 Gaining Goodwill with the Jurisdictions

The contact made with the jurisdictions during the plan review process, and possibly the field collection process, can be used to gain good will with the jurisdictions and discuss the problems and issues that they may be having with code implementation and enforcement. For future studies the following course of action is recommended:

Recommendations:

Plan extra time into each visit to the jurisdiction to meet with the building official, plan review staff and field inspection staff. This time can be used to discuss the possible adoption of a more current energy code or the problems and issues that they are having with enforcing the current energy code. This is also a time to collect information on future assistance that they may need to better enforce the energy codes. In addition, it is important to pass on, in a non-threatening manor, any problems that are found with respect to either the plan review or inspection process. The data collection staff must understand they are a guest in the jurisdiction and act accordingly.

Appendix I
Northern Nevada Jurisdictional Results

ANALYSIS SUMMARY – Carson City and County

Summary

- Sample Size
    - Plan Check- 9
    - Field Check- 17

Documentation Based on All Plan Checks

- Energy Code Compliance Documentation Submitted with 2 of 8 sample structures
- R-Values Shown on Plans of 1 of 8 structures
- NO U-Factors were shown on any plans

Pass/Fail of Each Code edition

Average Compliance Rate			Improvements Needed to Comply– Based on Field Inspection						
			Floor Insulation to R-19	Ceiling Insulation to R-38	Window Efficiency to .40 U-Factor	Furnace Efficiency to 90 AFUE	Wall Insulation to R-19	Slab Edge Insulation to R-10, 18”	Crawlspace Wall Insulation
	Plan Check	Field Inspection							
1992 MEC	-19.27%	-.79%	0	0	3	2	1	0	0
1993 MEC	-19.27%	-.79%	0	0	3	2	1	0	0
1995 MEC	-55.06%	-39.16%	8	0	3	2	1	0	0
1998 IECC	-61.10%	-39.16%	8	0	3	2	1	0	0
2000 IECC	-61.10%	-39.16%	8	0	3	2	1	0	0

Summary of Findings – Carson City and County
Based on Field Inspection – 8 Houses

Primary Roof: All Wood
Rafter/Joist Truss – 100%

Average Ceiling Insulation R-Value – 37.12

Primary Walls: Wood
Frame, 16” o.c. – 100%

Average Wall Insulation
R-Value – 16.39

Average Glazing
Square Footage-406

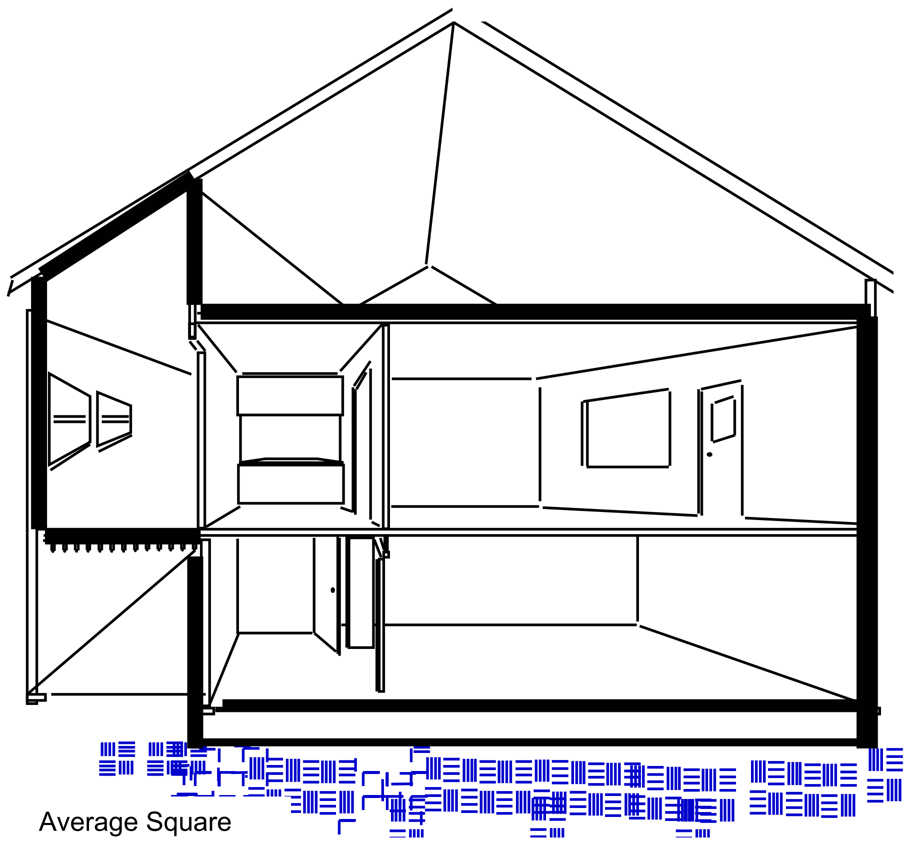
Typical Heating System- Gas
Heating 100%
Average AFUE- 84.33%

Average Glazing:Wall
Area Ratio-17%

Typical Glazing – Unlabled
88%

Typical Cooling System- Air
Cooled Air 100%
Average SEER- 10

Typical Entrance Door –
Fiberglass 50%
Steel Foam Core%



Average MecCheck Results

1992 MEC –0.79%
1993 MEC –0.79%
1995 MEC –39.16%
1998 IECC –39.16%
2000 IECC –39.16%

Average Square
Footage: 1992

Foundation: Crawlspace
Insulated Wall – 100%

Average Insulation
R-Value – 11

Foundation Systems

- Primary Foundation Type – All Field Inspected Structures in Carson City/County sample had Crawlspace Insulated Wall Foundations with R-11 insulation

- Primary Foundation Area/Linear Ft. – The average linear feet of foundation was 367.8 feet.

- Primary Foundation R-Value – The weighted average plan check Crawlspace wall insulation R-value was 11.5, all Field Inspected Structures in Carson City/County sample had R-11 insulation

- Primary Foundation Insulation Type – All Field Inspected Structures in Carson City/County sample had Continuous insulation

- Primary Foundation Insulation Dimensions A, B, C and D – Measured in Feet

	Dimension A	Dimension B	Dimension C	Dimension D
Crawlspace Wall Insulation	2.06	1.52	2.13	0.26

- Secondary Foundation Information

Four Field Inspected Homes had secondary foundations.

Secondary Foundation Types	Secondary Foundation Area/Linear Ft	Secondary R-Value	Foundation	Secondary Foundation Insulation Type
Plan Check Average R-Value:		19		
Crawlspace Insul Floor	148	19		Cavity
Crawlspace Insul Floor	318	19		Cavity
Crawlspace Insul Floor	16	19		Cavity
Crawlspace Insul Floor	441	19		Cavity

Wall Information

- Primary Wall
  - Type –all walls are 16” o.c. Wood studs
  - Area – 2227.25 Square Feet
  - Weighted Average of Insulation R-Value – Plan Check – 15.0, Field Inspection - 16.4

- Secondary Walls – 5 Field Inspected Structures had secondary wall systems, typically between the garage and house.
  - Type –all walls are 16” o.c. Wood studs
  - Area – 276.8 Square Feet
  - Weighted Average of Insulation R-Value – Plan Check – 13.8, Field Inspection - 13.5
  - Insulation Placement – Cavity

- Tertiary Walls – 1 Field Inspected Structure had a secondary wall system serving as a kneewall.
  - Type –all walls are 16” o.c. Wood studs

- Average Area – 254 Square Feet
- Weighted Average of Insulation R-Value – Plan Check – 17.8, Field Inspection - 19
- Insulation Placement – Cavity

Roof Information

- Primary Roof
  - Type – All primary roof structures in the Carson City/County Sample Set were All Wood Joist Rafter Truss Systems
  - Average Area – 1589.13 Square Feet
  - Weighted Average of Insulation R-Value – Plan Check – 34.1, Field Inspection - 37.1
  - Distribution of Insulation R-Values – 7, or 87.5% of the field inspected structures had R-38 insulation in the ceiling. The remainder had R-30.

- Secondary Roof Information – No Structures in the Carson City/County field inspection sample set had secondary roof structures

Window/Skylight Information

- Primary Window

Primary Window Type	
Unlabeled	87.75%
Vinyl	12.50%

  - Average Square Feet Glazing Area– Plan Check – 294.35, Field Inspection - 328.38
  - Weighted Average U- Factor – Plan Check - .55, Field Inspection - .44
  - Default U-factor used? – The default U-factor of .50 was not used in the field inspection home compliance calculations.

- Secondary Window Information When Applicable

Secondary Window Type	
Unlabeled	80%
Glass Block	12%

  - Average Square Feet Glazing Area– Plan Check – 76, Field Inspection - 123.8
  - Weighted Average U- Factor – Plan Check - .63, Field Inspection - .41
  - Default U-factor used? – The default U-factor of .6 was used in the glass block assembly

- Primary Skylight – There were no skylights in the Carson City/County sample set

Door Information – Field Inspection Data Only

- Main Entrance Door

Main Entrance Door - Type	
Fiberglass Ins	50%
Steel foam core	50%

- Average Area – 26.63 Square feet
- Weighted Average U-Factor - .34
- Default U-factor used? – 37.5% of structures
- No Storm Doors were reported

- Garage/House Door
  - Type – All "House/Garage" doors in the Carson City/County sample were solid core flush.
  - Average Area – 20.57 Square feet
  - Weighted Average U-Factor - ..38
  - Default U-factor used? – 37.5% of structures
  - No Storm Doors were reported

- Other Exterior Door
  - One "Other Exterior Door" was found in the Carson City/County sample, it was glass.
  - Average Area – 34 Square feet
  - Weighted Average U-Factor - .87
  - Default U-factor used? – No
  - No Storm Doors were reported

Duct Information– Field Inspection Data Only

- Return Duct
  - Location – All return duct systems were in the attic
  - Material Type – 88% were constructed of flex type ducting
  - Sealant – Distribution of sealant use is as follows:

Sealant Use	
Return Duct Sealant UL181 Tape	50%
Return Duct Sealant Mastic	0%
Return Duct Sealant Mastic+Tape	0%
Return Duct Sealant Duct Tape	50%
Return Duct Sealant Zip Ties	12.5%
Return Duct Sealant Screws	0%

  - Insulation R-Value – Average of 3.9

- Supply Duct
  - Location – All supply duct systems were in the attic
  - Material Type – All were constructed of flex type ducting
  - Sealant – Distribution of sealant use is as follows:

Sealant Use	
Supply Duct Sealant UL181 Tape	50%
Supply Duct Sealant Mastic	0%
Supply Duct Sealant Mastic+Tape	0%
Supply Duct Sealant Duct Tape	25%
Supply Duct Sealant Zip Ties	12.5%
Supply Duct Sealant Screws	0%

  - Insulation R-Value- Average of 3.9.

Mechanical System– Field Inspection Data Only

- Heating System
  - Heating System Type – All structures had Gas Furnaces
  - Efficiency – Average Efficiency was 84.33 AFUE
  - Default Used? – 25% percent of structures used default AFUE of 78
  - Secondary System Information – 1 structure had a secondary gas furnace system, with a default AFUE of 78.

- Cooling System
  - All of Structures had Air Conditioning – all were Air Cooled Air Systems.
  - Efficiency – Each had a SEER of 10
  - Efficiency Default of 4 was used 50% of the time.
  - Secondary System Information 6 structures had secondary cooling systems, five were air-cooled air, and one was a heat pump.
  - Efficiency – All had a SEER of 10
  - Efficiency Default of 10 was used 4 of 8 times, or 50% of the time.

Blower Door Testing– Field Inspection Data Only

- Air Changes Per Hour – .356
- Average Pan Pressure – 8.71

ANALYSIS SUMMARY – City of Lyon

Summary

- Sample Size
  - Plan Check- 21
  - Field Inspection- 12

Documentation – Based on all plan checks

- Energy Code Compliance Documentation NOT Submitted on any sample structures
- R-Values Shown on Plans of 4 of 12 field inspection structures
- NO U-Factors were shown on plans

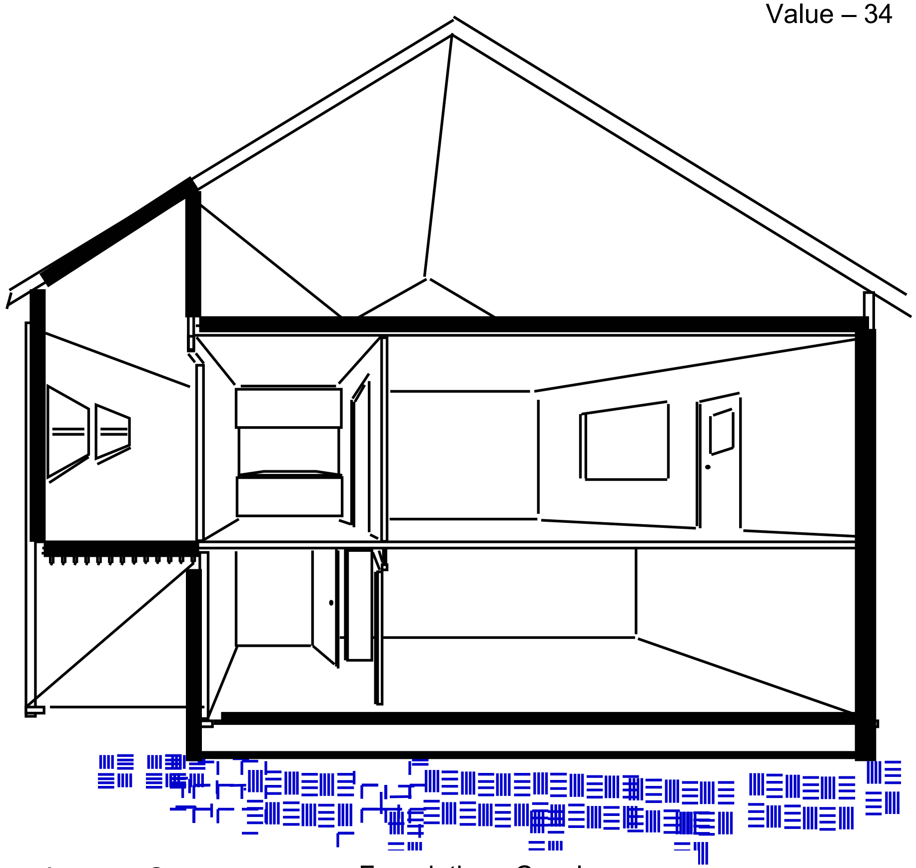
Pass/Fail of Each Code edition

			Improvements Needed to Comply – Based on Field Inspection						
Average Compliance Rate			Floor Insulation to R-19	Ceiling Insulation to R-38	Window Efficiency to .40 U-Factor	Furnace Efficiency to 90 AFUE	Wall Insulation to R-19	Slab Edge Insulation to R-10, 18”	Crawlspace Wall Insulation
	Plan Check	Field Inspection							
1992 MEC	-23.22	–22.02%	1	6	11	10	0	0	1
1993 MEC	-22.37	–22.02%	1	6	11	10	0	0	1
1995 MEC	-77.52	–68.00%	1	6	12	8	2	0	0
1998 IECC	-77.52	–68.00%	1	6	12	8	2	0	0
2000 IECC	-77.52	–68.00%	1	6	12	8	2	0	0

Summary of Findings – Lyon County
Based on Field Inspection – 12 Houses

Primary Roof: All Wood
Rafter/Joist Truss – 100%

Average Ceiling Insulation R-Value – 34



Average Glazing
Square Footage-259

Typical Glazing – Vinyl
Double Pane 58%

Average Glazing:Wall
Area Ratio-14.23%

Typical Entrance Door –
Steel Foam Core 50%

Average Square
Footage: 1640

Foundation: Crawlspace
Insulated Wall – 100%

Average Insulation
R-Value – 10.08

Primary Walls: Wood
Frame, 16” o.c. – 100%

Average Wall Insulation
R-Value – 14.9

Typical Heating System- Gas
Heating 100%
Average AFUE- 79%

Typical Cooling System- Air
Cooled Air 92%
Average SEER- 10

Average MecCheck Results

1992 MEC –22.02%
1993 MEC –22.02%
1995 MEC –68.00%
1998 IECC –68.00%
2000 IECC –68.00%

Foundation Systems

- Primary Foundation Type – All foundations in the Lyon County sample were Crawlspace Insulated Wall systems.
  - Primary Foundation Linear Ft. – Average 352 feet
  - Primary Foundation R-Value – Average Plan check- 11.4, Field Inspection10.1
  - Primary Foundation Insulation Type – Continuous
  - Primary Foundation Insulation Dimensions A, B, C and D – Measured in Feet

	Dimension A	Dimension B	Dimension C	Dimension D
Crawlspace Wall Insulation	1.67	1	1.74	0

- Secondary Foundation Information

1 Field Inspected home had a secondary foundation.

Secondary Foundation Types	Secondary Foundation Area/Linear Ft	Secondary R-Value	Foundation	Secondary Foundation Insulation Type
Crawlspace Insul Floor	643	0		N/A

Plan review of this structure showed R-19 insulation

Wall Information

- Primary Wall
  - Type –all walls are 16” o.c. Wood studs
  - Area – 1604.5 Square Feet
  - Weighted Average of Insulation R-Value – plan check- 12.9, field inspection - 14.9
- Secondary Walls – 9 Structures had secondary wall systems, typically between the garage and house.
  - Type –all walls are 16” o.c. wood studs
  - Average Area – 475 Square Feet
  - Weighted Average of Insulation R-Value – plan check – 12.9, field inspection - 14.1
- Tertiary Walls – 6 Structures had secondary wall systems, typically serving as kneewalls.
  - Type –all walls are 16” o.c. wood studs
  - Average Area – 124 Square Feet
  - Weighted Average of Insulation R-Value – plan check 15.2, field inspection - 15.8

Roof Information

- Primary Roof
  - Type – All primary roof structures in the Northern Nevada Sample Set were All Wood

Joist Rafter Truss Systems
- Average Area – 1577 Square Feet
- Weighted Average of Insulation R-Value – plan check – 31.5, field inspection - 34.4
- Distribution of Insulation R-Values – 6, or 50% of the structures had R-38 insulation in the ceiling. The remainder had R-30.

- Secondary Roof Information – 1 Structure included a Secondary Roof System
  - Type – All secondary roof structures were All Wood Joist Rafter Truss Systems
  - Average Area – 596 Square Feet
  - Weighted Average of Insulation R-Value – plan check – N/A, field inspection –38

Window/Skylight Information

- Primary Window

Primary Window Type	
Unlabeled	50%
Vinyl	50%

- Average Square Feet Glazing Area– plan check – 222.71, field inspection -237.83
- Weighted Average U- Factor – plan review - .55, field inspection .50
- Default U-factor used? – The default U-factor of .50 was used in 8.03 percent of field inspection compliance calculation

- Secondary Window Information – One structure in the Lyon County sample had secondary, metal windows, 10 square feet, with a U-factor of .5

Door Information – Field Inspection Data Only

- Main Entrance Door

Main Entrance Door - Type	
Fiberglass Ins	8%
Glass	8%
Steel foam core	50%
Solid core flush	33%

- Average Area – 21.67 Square feet
- Weighted Average U-Factor - .42
- Default U-factor used? – 83% of structures
- No Storm Doors were reported

- Garage/House Door – All Garage/House doors in the Lyon County sample were solid core flush.
  - Average Area – 17.83 Square feet
  - Weighted Average U-Factor - .37

- Default U-factor used? – 92% of structures
- Storm Door-No Storm Doors were reported

- Other Exterior Door – 3 structures In the Lyon County sample had "Other Exterior" doors, all were glass.
  - Average Area – 20 Square feet
  - Weighted Average U-Factor - .87
  - Default U-factor used? – 100% of structures
  - No Storm Doors were reported

Duct Information– Field Inspection Data Only

- Return Duct
  - Location – All of the return duct systems were in the attic
  - Material Type – 100% were constructed of flex type ducting
  - Sealant – Distribution of sealant use is as follows:

Sealant Use	
Return Duct Sealant UL181 Tape	16.67%
Return Duct Sealant Mastic	8.33%
Return Duct Sealant Mastic+Tape	0%
Return Duct Sealant Duct Tape	75%
Return Duct Sealant Zip Ties	25%
Return Duct Sealant Screws	8.33%

  - Insulation R-Value – All flex type ducts had an insulation level of 4.2.

- Supply Duct

Supply Duct Location	
Attic	25%
Crawlspace	58%

  - Material Type – 100% were constructed of flex type ducting
  - Sealant – Distribution of sealant use is as follows:

Sealant Use	
Supply Duct Sealant UL181 Tape	16.67%
Supply Duct Sealant Mastic	8.33%
Supply Duct Sealant Mastic+Tape	0%
Supply Duct Sealant Duct Tape	75%
Supply Duct Sealant Zip Ties	25%
Supply Duct Sealant Screws	8.33%

- Insulation R-Value- All flex type ducts had an insulation level of 4.2,

Mechanical System– Field Inspection Data Only

- Heating System
  - Heating System Type – All structures had Gas Furnaces
  - Efficiency – Average Efficiency was 79 AFUE
  - Default Used? – 50% percent of structures used default AFUE of 78

  - Secondary System Information – No structures had secondary gas furnace systems

- Cooling System - heating system comments apply here also
  - 92% of Structures had Air Conditioning – all were Air Cooled Air Systems.
  - Efficiency – Each had a SEER of 10
  - Efficiency Default of 10 was used 58% of the time.

  - Secondary System Information 2 structures had secondary cooling systems, 1 was air-cooled air, and one was a heat pump.
  - Efficiency – both had a SEER of 10
  - Efficiency Default of 10 was used 1 of 2 times, or 50% of the time.

Blower Door Testing– Field Inspection Data Only

- Air Changes Per Hour – 3.04
- Average Pan Pressure – 5.13

ANALYSIS SUMMARY – City of Reno

Summary

- Sample Size
  - Plan Check- 16
  - Field Inspection- 13

Documentation

- Energy Code Compliance Documentation Submitted 100% of the sample structures
- NO R-Values were shown on plans
- NO U-Factors were shown on plans

Pass/Fail of Each Code edition

			Improvements Needed to Comply – Based on Field Inspection								
Average Compliance Rate			Total Sample Size	Total Non-compliant Homes	Floor Insul. to R-19	Ceiling Insul. to R-38	Window U-factor to U-.40	Furnace Efficiency to 90 AFUE	Wall Insul. to R-19	Slab Edge Insul. to R-10, 18”	Crawlspace Wall Insulation
Code Year	Plan Check	Field Inspection									
1992	-8.32%	–8.63%	59	48	0	8	10	6	0	0	0
1993	-8.32%	–8.63%	59	48	0	8	10	6	0	0	0
1995	-26.04%	–33.78%	59	58	7	9	11	9	0	2	0
1998	-26.04%	–33.78%	59	58	7	9	11	9	0	2	0
2000	-26.04%	–33.78%	59	58	7	9	11	9	0	2	0

Summary of Findings – City of Reno
Based on Field Inspection - 13 Houses

Primary Roof: All Wood
Rafter/Joist Truss – 100%

Average Ceiling Insulation R-
Value – 33.52

Primary Walls: Wood
Frame, 16" o.c. – 100%

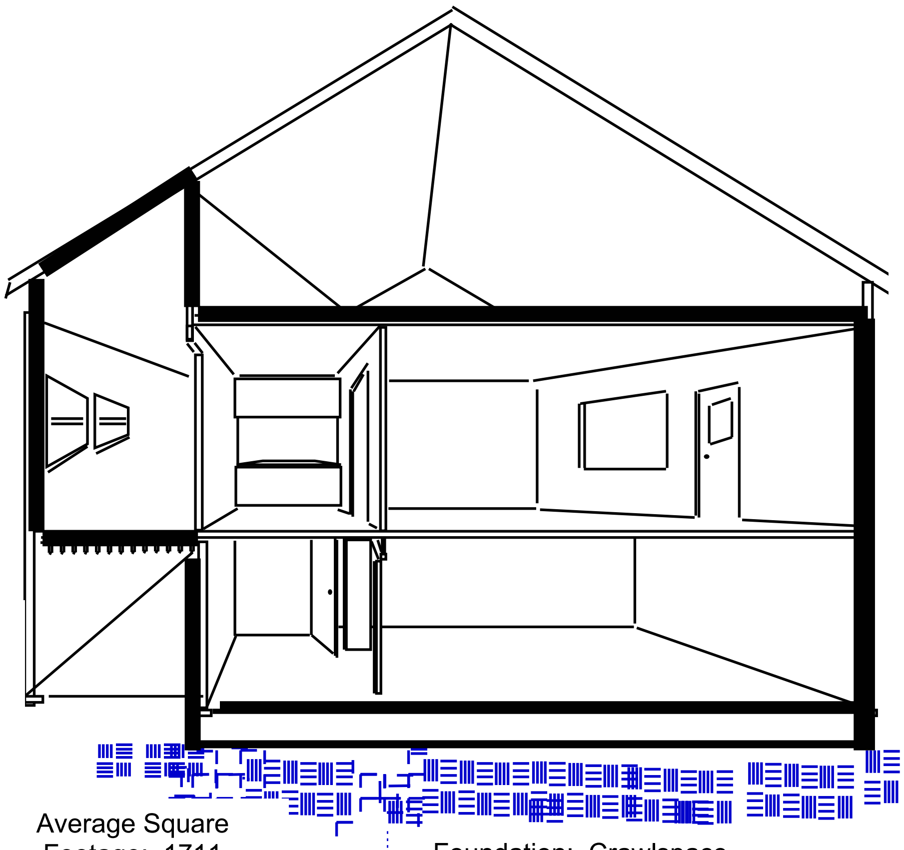
Average Wall Insulation
R-Value – 15.08

Average Glazing
Square Footage-290

Typical Glazing – Vinyl
Double Pane 100%

Average Glazing:Wall
Area Ratio-16%

Typical Entrance Door –
Steel Foam Core 54%



Typical Heating System- Gas
Heating 100%
Average AFUE- 80%

Typical Cooling System- Air
Cooled Air 69%
Average SEER- 10

Average Square
Footage: 1711

Foundation: Crawlspace
Insulated Wall – 62%

Average Insulation
R-Value – 11

<u>Average MecCheck Results</u>

1992 MEC –8.63%
1993 MEC –8.63%
1995 MEC –33.78%
1998 IECC –33.78%
2000 IECC –33.78%

Foundation Systems

Foundation System Type	
Crawlspace Wall Insulation	62%
Slab	15%
Crawlspace Insulated Floor	23%
	100.00%

Foundation Systems Area/Linear Ft.	
Crawlspace Wall Insulation	317
Slab	207
Crawlspace Insulated Floor	1811

Foundation Insulation R-Value		
	Plan Check	Field Inspection
Crawlspace Wall Insulation	9.2	11.0
Slab	0.0	0.0
Crawlspace Insulated Floor	19.0	14.8

- Primary Foundation Insulation Dimensions A, B, C and D – Measured in Feet

	Dimension A	Dimension B	Dimension C	Dimension D
Crawlspace Wall Insulation	1.22	0.91	1.22	0

- Secondary Foundations – No field inspected homes in the Reno study set had secondary foundations, the average crawlspace insulated wall insulation value in plan check was 16.54

Wall Information

- Primary Wall
    - Type –all walls are 16” o.c. Wood studs
    - Area – 1915 Square Feet
    - Weighted Average of Insulation R-Value – Plan check – 15.0, field inspection - 15.1
    - Insulation Placement
- Secondary Walls – 56 Structures had secondary wall systems, typically between the garage and house.
    - Type –all walls are 16” o.c. Wood studs
    - Area – 285 Square Feet
    - Weighted Average of Insulation R-Value – Plan Check – 14.1, field inspection – 14.0
    -

- Tertiary Walls – 40 Structures had secondary wall systems, typically serving as kneewalls.
    - Type –all walls are 16” o.c. Wood studs
    - Average Area – 295.5 Square Feet
    - Weighted Average of Insulation R-Value – plan check – 14.5, field inspection -14.0
    -

Roof Information

- Primary Roof
    - Type – All primary roof structures in the City of Reno sample set were All Wood Joist Rafter Truss Systems
    - Average Area – 1586 Square Feet
    - Weighted Average of Insulation R-Value – Plan check – 30.9, field inspection - 31.8
    - Distribution of Insulation R-Values – 3, or 23% of the structures had R-38 insulation in the ceiling. The remainder had R-30.

- Secondary Roof Information – 1 Structure included a Secondary Roof System
    - Type – All secondary roof structures were All Wood Joist Rafter Truss Systems
    - Average Area – 326 Square Feet
    - Weighted Average of Insulation R-Value, plan check – 30, field inspection - 38

Window/Skylight Information

- Primary Window – All primary windows were vinyl framed.

    - Average Square Feet Glazing Area– plan check – 274, field inspection - .99
    - Weighted Average U- Factor – plan check .50, field inspection .50
    - Default U-factor used? – The default U-factor of .50 was not used.

- Secondary Window Information – No secondary windows were reported in the Reno sample set

- Primary Skylight – No skylights were reported in the Reno sample set

Door Information – Field Inspection Data Only

- Main Entrance Door

Main Entrance Door - Type	
Steel foam core	54%
Solid core flush	46%

  - Average Area – 20.61 Square feet
  - Weighted Average U-Factor - .45
  - Default U-factor were used in 7.7% of the structures
  - No Storm Doors were reported

- Garage/House Door

House/Garage Doors	
Steel foam core	23%
Wood	7.7%
Solid core flush	61.5%

  - Average Area – 18.5 Square feet
  - Weighted Average U-Factor - .45
  - Default U-factor used? – 7.7% of structures
  - No Storm Doors were reported

- Other Exterior Door – One “Other Exterior” door was reported in the Reno sample set, a 17 square foot door, with a default U-factor of .56

Duct Information– Field Inspection Data Only

- Return Duct
  - Location – All of the return duct systems were in the attic.
  - Material Type – 77% were constructed of flex type ducting
  - Sealant – Distribution of sealant use is as follows:

Sealant Use	
Return Duct Sealant UL181 Tape	30.77%
Return Duct Sealant Mastic	0%
Return Duct Sealant Mastic+Tape	7.69%
Return Duct Sealant Duct Tape	61.53%
Return Duct Sealant Zip Ties	23.07%
Return Duct Sealant Screws	0%

  - Insulation R-Value – Average of 3.6

- Supply Duct
  - Location –

Supply Duct Location	
Attic	69%
Crawlspace	31%

  - Material Type – 77% were constructed of flex type ducting
  - Sealant – Distribution of sealant use is as follows:

Sealant Use	
Supply Duct Sealant UL181 Tape	30.76%
Supply Duct Sealant Mastic	0%
Supply Duct Sealant Mastic+Tape	7.69%
Supply Duct Sealant Duct Tape	61.54%
Supply Duct Sealant Zip Ties	23.07%
Supply Duct Sealant Screws	0%

  - Insulation R-Value- Average of 3.6

Mechanical System– Field Inspection Data Only

- Heating System
  - Heating System Type – All structures had Gas Furnaces
  - Efficiency – Average Efficiency was 79.8 AFUE
  - Default Used? – 7.7% percent of structures used default AFUE of 78
  - Secondary System Information – No secondary systems were reported

- Cooling System
  - 69% of Structures had Air Conditioning – all were Air Cooled Air Systems.
  - Efficiency – Each had a SEER of 10
  - Efficiency Default of 10 was not used.
  - Secondary System Information – No secondary cooling systems were reported

Blower Door Testing– Field Inspection Data Only

- Air Changes Per Hour – .49
- Average Pan Pressure – 5.78

ANALYSIS SUMMARY – Washoe County

Summary

- Sample Size
  - Plan Check- 16
  - Field Inspection- 14

Documentation

- Energy Code Compliance Documentation Submitted 35.7% of the sample structures
- R-Values Shown on Plans of 71% of the structures
- NO U-Factors were shown on plans

Pass/Fail of Each Code edition

			Improvements Needed to Comply based on field inspection						
Average Compliance Rate			Floor Insulation to R-19	Ceiling Insulation to R-38	Window Efficiency to .40 U-Factor	Furnace Efficiency to 90 AFUE	Wall Insulation to R-19	Slab Edge Insulation to R-10, 18"	Crawlspace Wall Insulation
	Plan Check	Field Inspection							
1992 MEC	-17%	–8.8%	0	8	10	7	0	1	1
1993 MEC	-17%	–8.8%	0	8	10	7	0	1	1
1995 MEC	-44.68%	–27.1%	7	8	10	7	0	1	0
1998 IECC	-44.68%	–27.1%	7	8	10	7	0	1	0
2000 IECC	-44.68%	–27.1%	7	8	10	7	0	1	0

Summary of Findings – Washoe County
Based on Field Inspection – 14 Houses

Primary Roof: All Wood
Rafter/Joist Truss – 100%

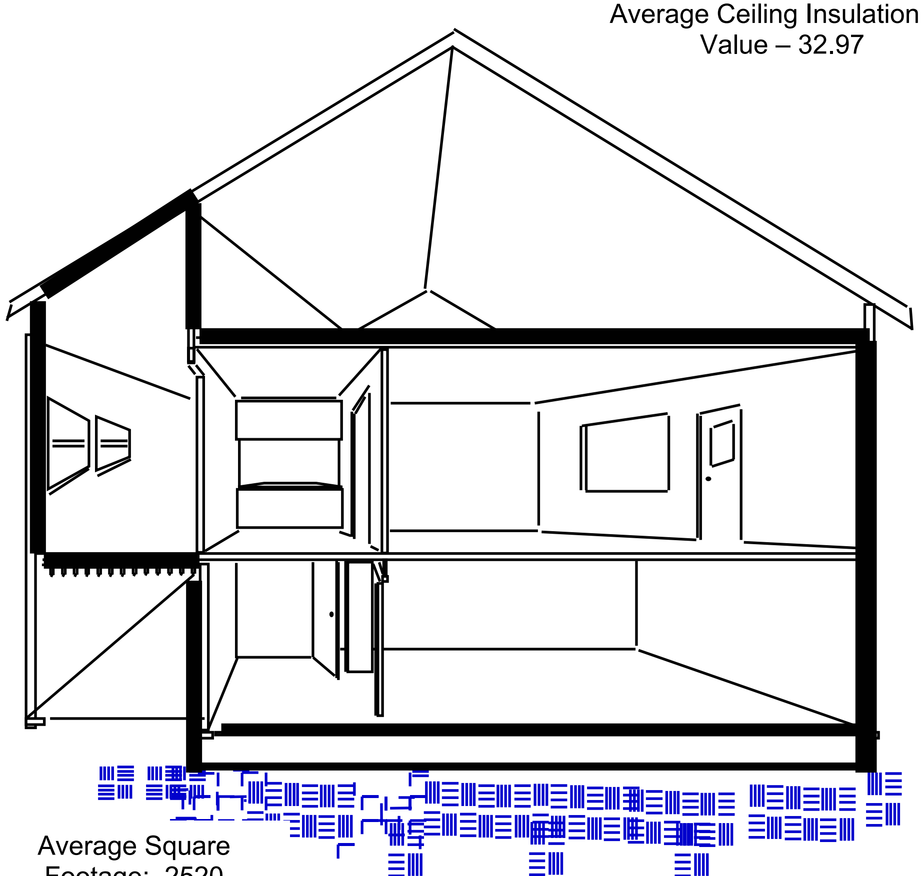
Average Ceiling Insulation R-Value – 32.97

Average Glazing
Square Footage-409

Typical Glazing – Vinyl
Framed 85%

Average Glazing:Wall
Area Ratio-17%

Typical Entrance Door –
Steel Foam Core 38%



Primary Walls: Wood
Frame, 16” o.c. – 100%

Average Wall Insulation
R-Value – 15.78

Typical Heating System- Gas
Heating 100%
Average AFUE- 80.64%

Typical Cooling System- Air
Cooled Air 84%
Average SEER- 10

Average Square
Footage: 2520

Foundation: Crawlspace
Insulated Wall – 54%

Average Insulation
R-Value – 12.14

Average MecCheck Results

1992 MEC –8.8%
1993 MEC –8.8%
1995 MEC –27.1%
1998 IECC –27.1%
2000 IECC –27.1%

Foundation Systems

Primary Foundation Type	
Crawlspace Wall Insulation	50%
Slab	7%
Crawlspace Insulated Floor	43%
	100.00%

Primary Foundation Area/Linear Ft.	
Crawlspace Wall Insulation	336.86
Slab	142.00
Crawlspace Insulated Floor	3139.66

Primary Foundation R-Value	Plan Check	Field Inspection
Crawlspace Wall Insulation	11.1	12.4
Slab	0.0	0.0
Crawlspace Insulated Floor	19.0	23.0

- Primary Foundation Insulation Dimensions A, B, C and D – Measured in Feet

	Dimension A	Dimension B	Dimension C	Dimension D
Crawlspace Wall Insulation	1.85	1.35	2	0

- Secondary Foundation Information

3 Homes had secondary foundations.

Secondary Foundation Types	Secondary Foundation Area/Linear Ft	Secondary Foundation R-Value	Secondary Foundation Insulation Type
Crawlspace Insul Floor	26	19	Cavity
Crawlspace Insul Floor	240	19	Cavity
Slab	33	0	N/A

Plan-reviewed homes had an average R-19 in secondary foundations, all crawlspace insulated floor systems.

Wall Information

- Primary Wall
    - Type –all walls are 16” o.c. Wood studs
    - Area – 2188 Square Feet
    - Weighted Average of Insulation R-Value – plan check – 14.0, field inspection - 15.8

- Secondary Walls – 3 Structures had secondary wall systems, typically between the garage and house.
    - Type –all walls are 16” o.c. Wood studs
    - Area – 256 Square Feet
    - Weighted Average of Insulation R-Value – plan check – 13.8, field inspection –13.0

- Tertiary Walls – 3 field inspected structures had secondary wall systems, typically serving as kneewalls.
    - Type –all walls are 16” o.c. Wood studs
    - Average Area – 88 Square Feet
    - Weighted Average of Insulation R-Value – plan check 15.0, field inspection - 13

Roof Information

- Primary Roof
    - Type – All primary roof structures in the Northern Nevada Sample Set were All Wood Joist Rafter Truss Systems
    - Average Area – 2216 Square Feet
    - Weighted Average of Insulation R-Value – plan check – 31.8, field inspection – 33.0
    - Distribution of Insulation R-Values – 4, or 29% of the structures had R-38 insulation in the ceiling. The remainder had R-30.

- Secondary Roof Information – 2 Structures included Secondary Roof Systems
    - Type – All secondary roof structures were All Wood Joist Rafter Truss Systems
    - Average Area – 870 Square Feet
    - Weighted Average of Insulation R-Value – plan check N/A, field inspection 36.8

Window/Skylight Information

Primary Window Type	
Unlabeled	14.28%
Vinyl	78.57%
Vinyl Low E Argon	7.14%

- Average Square Feet Glazing Area– plan check 292.43, field inspection 379.36
- Weighted Average U- Factor – plan check .55, field inspection .49
- Default U-factor used? – the default U-factor of .50 was used in 21.43 percent of homes

- Secondary Window Information – 8 field inspection structures included secondary window systems

Secondary Window Type	
Unlabeled	12.50%
Vinyl	87.50%

  - Average Square Feet Glazing Area– plan check 77, field inspection 50.5
  - Weighted Average U- Factor – plan check .55, field inspection .39
  - Default U-factor used? – the default U-factor of .50 was used in 3, or 37.5% of homes with secondary windows

- Primary Skylight – One case of skylights was recorded in the Washoe County sample

Primary Skylight Type	Square Feet	U-Factor	Default U-factor used?
Vinyl Framed	30	0.84	TRUE

Door Information – Field Inspection Data Only

- Main Entrance Door

Main Entrance Door - Type	
Fiberglass Ins	21.43%
Glass	7.14%
Steel foam core	42.85%
Wood w 7/16	14.28%
Wood w 9/8	0%
Wood	7.14%
Solid core flush	7.14%
Unlabeled	0%

  - Average Area – 24.43 Square feet
  - Weighted Average U-Factor - .38.57
  - Default U-factor used? – 92.86% of structures
  - No Storm Doors were reported

- Garage/House Door– Field Inspection Data Only

House/Garage Doors	
Fiberglass Ins	0.00%
Glass	0.00%
Steel foam core	14.29%
Wood w 7/16	0.00%
Wood w 9/8	0.00%
Wood	7.14%
Solid core flush	78.57%
Unlabeled	0.00%

  - Average Area – 18.5 Square feet
  - Weighted Average U-Factor - .39
  - Default U-factor used? – 100% of structures
  - No Storm Doors were reported

- Other Exterior Door – 5 “Other Exterior” doors were reported in the Washoe County sample

Other Exterior Doors	
Glass	7.14%
Steel foam core	7.14%
Half Light	85.72%

  - Average Area – 18.5 Square feet
  - Weighted Average U-Factor - .52
  - Default U-factor used? – 80% of structures
  - -No Storm Doors were reported

Duct Information– Field Inspection Data Only

- Return Duct
  - Location – 10 of the return duct systems were in the attic, 2 in were located in both attic and crawlspace, and 1 in the crawlspace.
  - Material Type – 86% were constructed of flex type ducting, 7% were constructed of sheet metal.

- Sealant – Distribution of sealant use is as follows:

Sealant Use	
Return Duct Sealant UL181 Tape	14.28%
Return Duct Sealant Mastic	0%
Return Duct Sealant Mastic+Tape	0%
Return Duct Sealant Duct Tape	64.28%
Return Duct Sealant Zip Ties	42.85%
Return Duct Sealant Screws	7.14%

- Insulation R-Value – All flex type ducts had an insulation level of 4.2, however the use of sheet metal in several homes reduced the average R-value to 4.17.

- Supply Duct
  - Location –

Supply Duct Location	
Attic	35.71%
Crawlspace	42.86%
Both	14.28%

  - Material Type – 86% were constructed of flex type ducting
  - Sealant – Distribution of sealant use is as follows:

Sealant Use	
Supply Duct Sealant UL181 Tape	14.28%
Supply Duct Sealant Mastic	0%
Supply Duct Sealant Mastic+Tape	0%
Supply Duct Sealant Duct Tape	64.28%
Supply Duct Sealant Zip Ties	42.85%
Supply Duct Sealant Screws	7.14%

  - Insulation R-Value- The average was 4.17.

Mechanical System– Field Inspection Data Only

- Heating System
  - Heating System Type – All structures had Gas Furnaces
  - Efficiency – Average Efficiency was 80.6 AFUE
  - Default Used? – 7.14% percent of structures used default AFUE of 78
  - Secondary System Information – 1 structure had a secondary gas furnace system with an AFUE of 90.

- Cooling System - heating system comments apply here also
  - 86% of Structures had Air Conditioning – all were Air Cooled Air Systems.
  - Efficiency – Each had a SEER of 10
  - Efficiency Default of 10 was used 42% of the time.

  - Secondary System Information 3 structures had secondary cooling systems, all air cooled air
  - Efficiency – 2 had a SEER of 10, one had a SEER of 12
  - Efficiency Default was not used

Blower Door Testing– Field Inspection Data Only

- Air Changes Per Hour – .32
- Average Pan Pressure – 18.62

ANALYSIS SUMMARY – City of Sparks

Summary

- Sample Size
  - Plan Check- 20
  - Field Inspection- 12

Documentation

- Energy Code Compliance Documentation Submitted 58.3% of the sample structures
- R-Values Shown on Plans of 25% of the structures
- NO U-Factors were shown on plans

Pass/Fail of Each Code edition

			Improvements Needed to Comply – based on field inspection						
Average Compliance Rate			Floor Insulation to R-19	Ceiling Insulation to R-38	Window Efficiency to .40 U-Factor	Furnace Efficiency to 90 AFUE	Wall Insulation to R-19	Slab Edge Insulation to R-10, 18"	Crawlspace Wall Insulation
	Plan Check	Field Inspection							
1992 MEC	-15.60%	–11.7%	0	5	11	6	1	1	1
1993 MEC	-15.60%	–11.7%	0	5	11	6	1	1	1
1995 MEC	-36.24%	–44.61%	9	5	11	6	0	1	0
1998 IECC	-36.24%	–44.61%	9	5	11	6	0	1	0
2000 IECC	-36.24%	–44.61%	9	5	11	6	0	1	0

Summary of Findings – City of Sparks
Based on Field Inspection – 12 Houses

Primary Roof: All Wood Rafter/Joist Truss – 100%

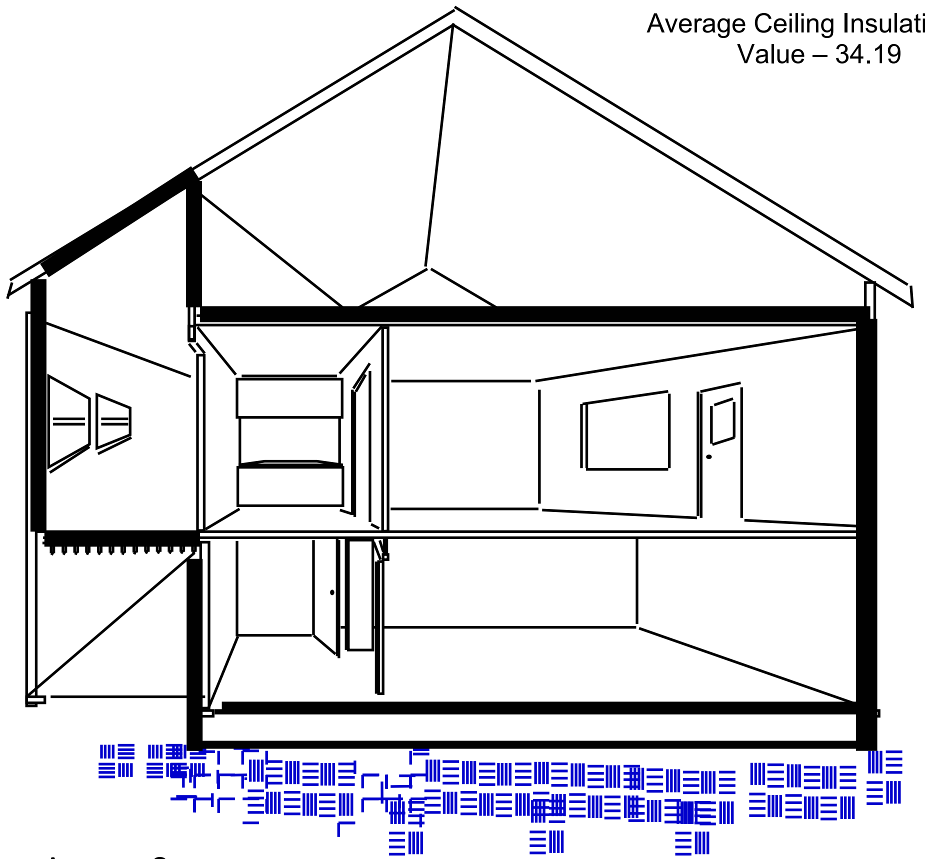
Average Ceiling Insulation R-Value – 34.19

Average Glazing Square Footage-453

Typical Glazing – Vinyl Double Pane 75%

Average Glazing:Wall Area Ratio-17%

Typical Entrance Door – Steel Foam Core 42%



Primary Walls: Wood Frame, 16" o.c. – 100%

Average Wall Insulation R-Value – 17.56

Typical Heating System- Gas Heating 100%
Average AFUE- 78%

Typical Cooling System- Air Cooled Air 88%
Average SEER- 10

Average Square Footage: 2154

Foundation: Crawlspace Insulated Wall – 75%

Average Insulation R-Value – 15.67

<u>Average MecCheck Results</u>

1992 MEC –11.7%
1993 MEC –11.7%
1995 MEC –44.61%
1998 IECC –44.61%
2000 IECC –44.61%

Foundation Systems

Primary Foundation Type	
Crawlspace Wall Insulation	75%
Slab	8.33%
Crawlspace Insulated Floor	16.67%
	100.00%

Primary Foundation Area/Linear Ft.	
Crawlspace Wall Insulation	395
Slab	156
Crawlspace Insulated Floor	1853

Primary Foundation R-Value		
	Plan Check	Field Inspection
Crawlspace Wall Insulation	16.1	15.6
Slab	0	0
Crawlspace Insulated Floor	17.2	19.0

- Primary Foundation Insulation Dimensions A, B, C and D – Measured in Feet

	Dimension A	Dimension B	Dimension C	Dimension D
Crawlspace Wall Insulation	1.5	1.03	1.67	.67

- Secondary Foundation – Structures in the Sparks sample had secondary foundations

Wall Information

- Primary Wall
    - Type –all walls are 16” o.c. Wood studs
    - Area – 2438 Square Feet
    - Weighted Average of Insulation R-Value – plan check 15.8, field inspection 17.6

- Secondary Walls – All 12 field inspection structures had secondary wall systems, typically between the garage and house.
    - Type –all walls are 16” o.c. Wood studs
    - Area – 255Square Feet
    - Weighted Average of Insulation R-Value – plan check 13.96, field inspection13.4

- Tertiary Walls – 11 Structures had secondary wall systems, typically serving as kneewalls.
    - Type –all walls are 16” o.c. Wood studs
    - Average Area – 228 Square Feet
    - Weighted Average of Insulation R-Value – plan check 13.9, field inspection 13.5

Roof Information

- Primary Roof
  - Type – All primary roof structures in the Sparks Sample Set were All Wood Joist Rafter Truss Systems
  - Average Area – 1875 Square Feet
  - Weighted Average of Insulation R-Value – plan check 32.4, field inspection 34.2
  - Distribution of Insulation R-Values – 6, or 50% of the field inspection structures had R-38 insulation in the ceiling. The remainder had R-30.

  - Secondary Roof Information – No secondary roof structures were reported

Window/Skylight Information

- Primary Window

Primary Window Type	
Unlabeled	25%
Metal	8%
Vinyl	66%

  - Average Square Feet Glazing Area– plan check 398, field inspection 332
  - Weighted Average U- Factor – plan check .55, field inspection .50
  - Default U-factor used? – the default U-factor of .50 was not used

- Secondary Window s – 11 structures in the Sparks field inspection sample set had secondary window systems

Secondary Window Type	
Unlabeled	18%
Metal	9%
Vinyl	73%
Glass Block	0%

  - Average Square Feet Glazing Area– plan check 85, field inspection 78.68
  - Weighted Average U- Factor – plan check .55, field inspection .50
  - Default U-factor used? – the default U-factor of .50 was not used.

- Primary Skylight – One case of skylights was recorded in the Sparks sample

Primary Skylight Type	Square Feet	U-Factor	Default U-factor used?
Metal	110	1.89	TRUE

Door Information – Field Inspection Data Only

- Main Entrance Door

Main Entrance Door - Type	
Fiberglass Ins	16%
Glass	0%
Steel foam core	42%
Wood w 7/16	0%
Wood w 9/8	8%
Wood	0%
Solid core flush	28%
Unlabeled	1.69%

  - Average Area – 22.33 Square feet
  - Weighted Average U-Factor - .35
  - Default U-factor was not used.
  - No Storm Doors were reported

- Garage/House Door

House/Garage Doors	
Fiberglass Ins	8%
Glass	0.00%
Steel foam core	0%
Wood w 7/16	0.00%
Wood w 9/8	0.00%
Wood	0.00%
Solid core flush	92%
Unlabeled	0.00%

  - Average Area – 19.5 Square feet
  - Weighted Average U-Factor - .37
  - Default U-factor used? – 66.6% of structures
  - No Storm Doors were reported

- Other Exterior Door – 3 structures in the sample set were reported to have “Other Exterior” doors; they were glass, with a default U-factor of .87. The average square footage was 94. No Storm Doors were reported

Duct Information– Field Inspection Data Only

- Return Duct
  - Location – 10 of the return duct systems were in the attic
  - Material Type – 92% were constructed of flex type ducting
  - Sealant – Distribution of sealant use is as follows:

Sealant Use	
Return Duct Sealant UL181 Tape	75.00%
Return Duct Sealant Mastic	0.00%
Return Duct Sealant Mastic+Tape	0.00%
Return Duct Sealant Duct Tape	8.33%
Return Duct Sealant Zip Ties	16.67%
Return Duct Sealant Screws	0%

  - Insulation R-Value – All flex type ducts had an insulation level of 4.2

- Supply Duct
  - Location –

Supply Duct Location	
Attic	16.67%
Crawlspace	50.00%
Both	8.33%

  - Material Type – 92% were constructed of flex type ducting, 8% were constructed of sheet metal
  - Sealant – Distribution of sealant use is as follows:

Sealant Use	
Supply Duct Sealant UL181 Tape	91.67%
Supply Duct Sealant Mastic	0.00%
Supply Duct Sealant Mastic+Tape	0.00%
Supply Duct Sealant Duct Tape	8.33%
Supply Duct Sealant Zip Ties	16.67%
Supply Duct Sealant Screws	0.00%

  - Insulation R-Value- All flex type ducts had an insulation level of 4.2, however the use of sheet metal reduced the average R-value to 3.9.

Mechanical System– Field Inspection Data Only

- Heating System

  - Heating System Type – All structures had Gas Furnaces
  - Efficiency – Average Efficiency was 78 AFUE
  - Default Used? – 58.33% percent of structures used default AFUE of 78

  - Secondary System Information – No secondary systems were reported

- Cooling System - heating system comments apply here also
  - 100% of Structures had Air Conditioning – all were Air Cooled Air Systems.
  - Efficiency – Each had a SEER of 10
  - Efficiency Default of 10 was used 50% of the time.

  - Secondary System Information No secondary systems were reported

Blower Door Testing– Field Inspection Data Only

- Air Changes Per Hour – .318
- Average Pan Pressure – 6.36

Appendix II
Southern Nevada Jurisdictional Results

ANALYSIS SUMMARY – Southern Nevada

Summary

- Sample Size
    - Plan Check- 102
    - Field Inspection- 13

Documentation

- Energy Code Compliance Documentation Submitted 92% of the sample structures
- R-Values Shown on Plans of 16% of the structures
- U-Factors Shown on Plans 3% of the structures

Pass/Fail of Each Code edition

– ALL field inspected structures surveyed in Southern Nevada complied with the IECC for each of the code editions 1992-2000.

ANALYSIS SUMMARY – Clark County

Summary

- Sample Size
    - Plan Check- 38
    - Field Inspection- 3

Documentation

- Energy Code Compliance Documentation Submitted 92% of the sample structures
- R-Values Shown on Plans of 34% of the structures
- U-Factors Shown on Plans 8% of the structures

Pass/Fail of Each Code edition

ALL field inspected structures surveyed in Clark County complied with the IECC for each of the code editions 1992-2000.

Summary of Findings – Clark County
Based on field inspections in Clark County – 3 Houses

Primary Roof: All Wood
Rafter/Joist Truss – 92%

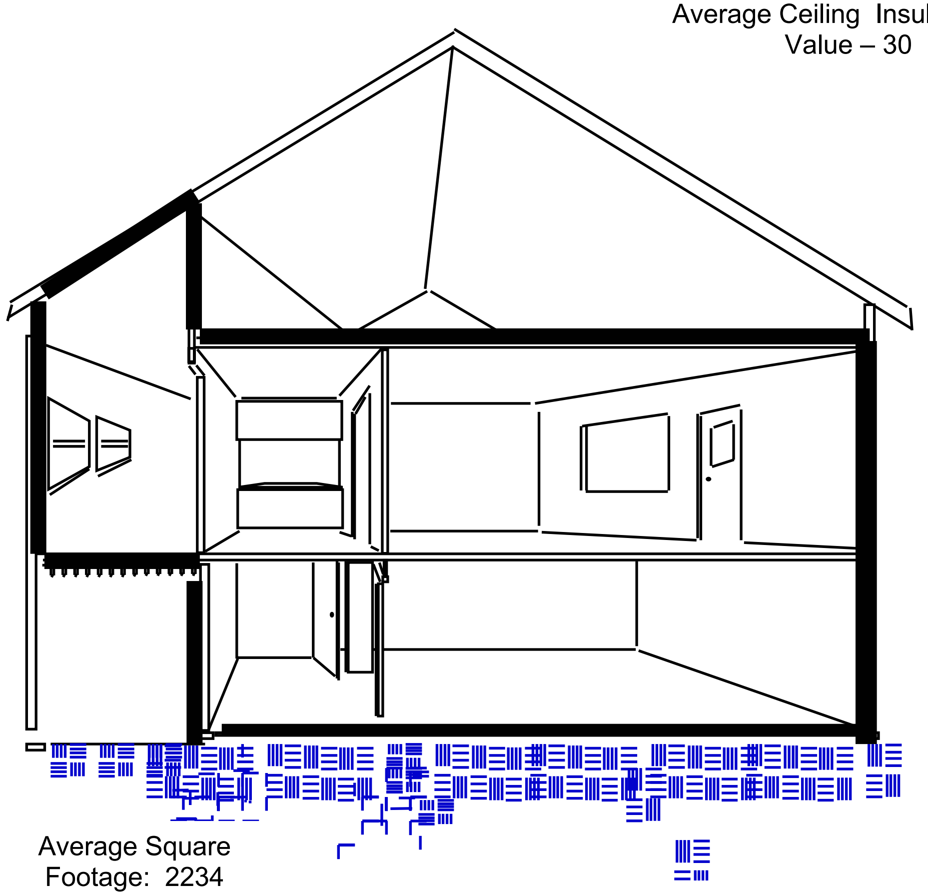
Average Ceiling Insulation R-Value – 30

Average Glazing
Square Footage-316

Typical Glazing – Metal
Framed 100%

Average Glazing:Wall
Area Ratio-12%

Typical Entrance Door –
Steel Foam Core 100%



Primary Walls: Wood
Frame, 16" o.c. – 100%

Average Wall Insulation
R-Value – 17

Typical Heating System- Gas
Heating 100%
Average AFUE- 80%

Typical Cooling System- Air
Cooled Air 100%
Average SEER- 10

Average Square
Footage: 2234

Foundation: Slab – 100%

Average Insulation
R-Value – 0

<u>Average MecCheck Results</u>

1992 MEC 12.80%
1993 MEC 11.20%
1995 MEC 9.63%
1998 IECC 9.63%
2000 IECC 9.63%

Foundation Systems

- Primary Foundation Type – All Structures surveyed had slab foundations
- Primary Foundation Average Linear Ft. – 162
- Primary Foundation R-Value – No structures surveyed had insulated slabs.
- Secondary Foundation Information When Applicable

2 Homes had secondary foundations.

Secondary Foundation Type	Secondary Foundation Area/Linear Ft	Secondary R-Value	Foundation	Secondary Foundation Insulation Type
Crawlspace Insul Floor	475	19		Cavity
Crawlspace Insul Floor	526	19		Cavity

Plan Check average insulation for Crawlspace insulated floors was 20.37

Wall Information

- Primary Wall
    - Type –all walls are 16” o.c. Wood studs
    - Area – 2151 Square Feet
    - Weighted Average of Insulation R-Value – plan check 13.8, field inspection 17.0
- Secondary Walls – All 3 structures had secondary wall systems, typically between the garage and house.
    - Type –all walls are 16” o.c. Wood studs
    - Area – 314 Square Feet
    - Weighted Average of Insulation R-Value – plan check 12.3, field inspection 13.0
- Tertiary Walls – All 3 structures had secondary wall systems, typically serving as kneewalls.
    - Type –all walls are 16” o.c. Wood studs
    - Average Area – 125 Square Feet
    - Weighted Average of Insulation R-Value – plan check 12.6, field inspection 19.0

Roof Information

- Primary Roof
    - Type – All 3 primary roof structures in the Clark County Sample Set were All Wood Joist Rafter Truss Systems
    - Average Area – 1777 Square Feet
    - Weighted Average of Insulation R-Value –plan check 29.7, all field inspected roofs were insulated to R-30
- Secondary Roof Information – No structures in the Clark County sample had Secondary Roof Systems

Window/Skylight Information

- Primary Window - All windows surveyed were aluminum framed, double paned.
  - Average Square Feet Glazing Area– plan check 267, field inspection 268
  - Weighted Average U- Factor – plan check .77, field inspected .75
  - Default U-factor used? – the default U-factor of .50 was not used
  - Weighted average SHCG - .64

- Secondary Windows – 2 of the 3 structures had secondary window systems
  - Average Square Feet Glazing Area– plan check 97, field inspection 68.5
  - Weighted Average U- Factor – plan check .69, field inspection .62
  - Default U-factor used? – the default U-factor of .50 was not used
  - Weighted average SHCG - .58

- Skylight – No skylights were recorded in the Clark County sample

Door Information – Field inspection data only

- Main Entrance Door

Main Entrance Door - Type	
Steel foam core	100%

  - Average Area – 22.67 Square feet
  - Weighted Average U-Factor - ..33
  - Default U-factor used was not used.
  - No Storm Doors were reported

- Garage/House Door
  - Type – All House/Garage Doors were Solid Core Flush
  - Average Area – 20 Square feet
  - Weighted Average U-Factor - .38
  - Default U-factor was not used
  - No Storm Doors were reported

- Other Exterior Door
  - One “Other Exterior Doors” was found, it was glass.
  - Average Area – 18 Square feet
  - Weighted Average U-Factor - .8
  - Default U-factor was used.
  - No Storm Doors were reported

Duct Information– Field inspection data only

- Return Duct
  - Location – All of the return duct systems were in the attic.
  - Material Type – All were constructed of flex type ducting

- Sealant – Distribution of sealant use is as follows:

Sealant Use	
Return Duct Sealant UL181 Tape	100%
Return Duct Sealant Mastic	100%
Return Duct Sealant Mastic+Tape	0%
Return Duct Sealant Duct Tape	0%
Return Duct Sealant Zip Ties	100%
Return Duct Sealant Screws	0%

- Insulation R-Value – All flex type ducts had an insulation level of 4.2.

- Supply Duct
  - Location – All of the return duct systems were in the attic.
  - Material Type – All were constructed of flex type ducting
  - Sealant – Distribution of sealant use is as follows:

Sealant Use	
Supply Duct Sealant UL181 Tape	100%
Supply Duct Sealant Mastic	100%
Supply Duct Sealant Mastic+Tape	0%
Supply Duct Sealant Duct Tape	0%
Supply Duct Sealant Zip Ties	100%
Supply Duct Sealant Screws	0%

  - Insulation R-Value- All flex type ducts had an insulation level of 4.2.

Mechanical System– Field inspection data only

- Heating System
  - Heating System Type – All structures had Gas Furnaces
  - Efficiency – All systems had an AFUE of 80
  - Default AFUE was not used.
    - No secondary systems were reported

- Cooling System -
  - 100% of Structures had Air Conditioning – all were Air Cooled Air Systems.
  - Efficiency – Each had a SEER of 10
  - Efficiency Default of 10 was used 1, or 33% of the time.
  - No secondary systems were reported

Blower Door Testing– Field inspection data only

- Air Changes Per Hour – .27
- Average Pan Pressure – .51

ANALYSIS SUMMARY – City of Henderson

Summary

- Sample Size
  - Plan Check- 38
  - Field Inspection- 2

Documentation

- Energy Code Compliance Documentation Submitted 50% of the sample structures
- R-Values Shown on Plans of 50% of structures
- NO U-Factors were shown on plans

Pass/Fail of Each Code edition

ALL field inspected structures surveyed in Clark County complied with the IECC for each of the code editions 1992-2000.

Summary of Findings – City of Henderson
Based on field inspections in City of Henderson – 2 Houses

Primary Roof: All Wood
Rafter/Joist Truss – 100%

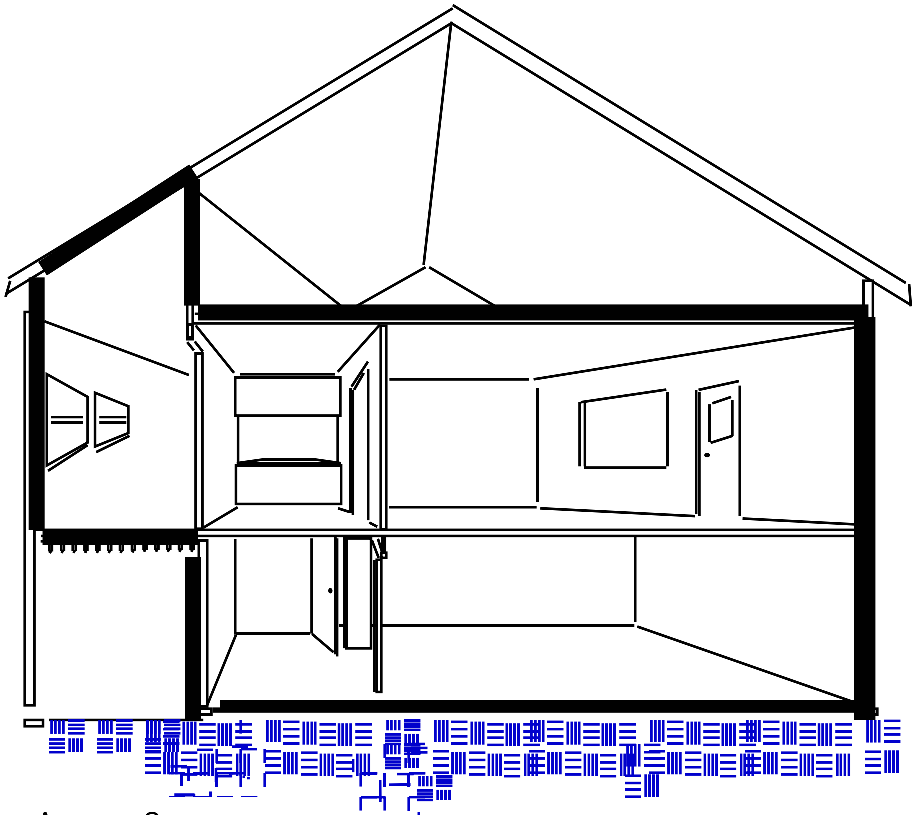
Average Ceiling Insulation R-Value – 30

Average Glazing
Square Footage-522

Typical Glazing – Metal
Framed 100%

Average Glazing:Wall
Area Ratio-15.3%

Typical Entrance Door –
Steel Foam Core 100%



Primary Walls: Wood
Frame, 16” o.c. – 100%

Average Wall Insulation
R-Value – 17

Typical Heating System- Gas
Heating 100%
Average AFUE- 80%

Typical Cooling System- Air
Cooled Air 100%
Average SEER- 10

Average Square
Footage: 3647

Foundation: Slab – 100%

Average Insulation
R-Value – 0

Average MecCheck Results

1992 MEC 12.30%
1993 MEC 11.20%
1995 MEC 8.90%
1998 IECC 8.90%
2000 IECC 8.90%

Foundation Systems

- Primary Foundation Type – All Structures surveyed had slab foundations
- Primary Foundation Average Linear Ft. – 220
- Primary Foundation R-Value – No structures surveyed had insulated slabs.
- Secondary Foundation Information

2 Homes had secondary foundations.

Secondary Foundation Type	Secondary Foundation Area/Linear Ft	Secondary R-Value	Foundation	Secondary Foundation Insulation Type
Slab	45	0		N/A
Crawlspace Insul Floor	515	19		Cavity

Plan Check average insulation for Crawlspace insulated floors was 17.71

Wall Information

- Primary Wall
  - Type –all walls are 16" o.c. Wood studs
  - Area – 2151 Square Feet
  - Weighted Average of Insulation R-Value – plan check 16.1, field inspection17.0
- Secondary Walls – 3 Structures had secondary wall systems, typically between the garage and house.
  - Type –all walls are 16" o.c. Wood studs
  - Area – 314 Square Feet
  - Weighted Average of Insulation R-Value – plan check 14.1, field inspection13.0
- Tertiary Walls – 3 Structures had secondary wall systems, typically serving as kneewalls.
  - Type –all walls are 16" o.c. Wood studs
  - Average Area – 125 Square Feet
  - Weighted Average of Insulation R-Value – plan check 14.7, field inspection19.0

Roof Information

- Primary Roof
  - Type – All 3 primary roof structures in the Henderson Sample Set were All Wood Joist Rafter Truss Systems, 1 was an Oversized Joist system.
  - Average Area – 2822 Square Feet
  - Weighted Average of Insulation R-Value –All Roofs were insulated to R-30 in both plan check and field inspection
- Secondary Roof Information – No structures in the Henderson sample had Secondary Roof Systems

Window/Skylight Information

- Primary Window - All windows surveyed were aluminum framed, double paned.
  - Average Square Feet Glazing Area– plan check 282, field inspection 373
  - Weighted Average U- Factor – plan check .75, field inspection 72
  - Default U-factor used? – the default U-factor of .50 was not used
  - weighted average SHCG - .55

- Secondary Windows – both structures had secondary window systems
  - Average Square Feet Glazing Area– plan check 88, field inspection100.5
  - Weighted Average U- Factor – plan check .66, field inspection .51
  - Default U-factor used? – the default U-factor of .50 was not used
  - Weighted average SHCG - .52

- Skylight – No skylights were recorded in Henderson

Door Information – Field inspection data only

- Main Entrance Door

Main Entrance Door - Type	
Steel foam core	100%

  - Average Area – 48 Square feet
  - Weighted Average U-Factor - .42
  - Default U-factor used was not used.
  - No Storm Doors were reported

- Garage/House Door
  - Type – Both House/Garage Doors were Solid Core Flush
  - Average Area – 18 Square feet
  - Weighted Average U-Factor - .33
  - Default U-factor was not used
  - No Storm Doors were reported

- Other Exterior Door
  - One “Other Exterior Doors” were found, it was glass.
  - Average Area – 80 Square feet
  - Weighted Average U-Factor - .87
  - Default U-factor was not used.
  - No Storm Doors were reported

Duct Information - Field inspection data only

- Return Duct
  - Location – All of the return duct systems were in the attic.
  - Material Type – All were constructed of flex type ducting
  - Sealant – Distribution of sealant use is as follows:

Sealant Use	
Return Duct Sealant UL181 Tape	50%
Return Duct Sealant Mastic	100%
Return Duct Sealant Mastic+Tape	0%
Return Duct Sealant Duct Tape	0%
Return Duct Sealant Zip Ties	100%
Return Duct Sealant Screws	0%

  - Insulation R-Value – All flex type ducts had an insulation level of 4.2.

- Supply Duct
  - Location – All of the return duct systems were in the attic.
  - Material Type – All were constructed of flex type ducting
  - Sealant – Distribution of sealant use is as follows:

Sealant Use	
Supply Duct Sealant UL181 Tape	50%
Supply Duct Sealant Mastic	100%
Supply Duct Sealant Mastic+Tape	0%
Supply Duct Sealant Duct Tape	0%
Supply Duct Sealant Zip Ties	100%
Supply Duct Sealant Screws	0%

  - Insulation R-Value- All flex type ducts had an insulation level of 4.2.

Mechanical System - Field inspection data only

- Heating System
  - Heating System Type – All structures had Gas Furnaces
  - Efficiency – All systems had an AFUE of 80
  - Default AFUE was not used

    - No secondary systems were reported

Cooling System -

- 100% of Structures had Air Conditioning – all were Air Cooled Air Systems.
- Efficiency – Each had a SEER of 10
- Efficiency Default of 10 was not used.
- No secondary systems were reported

Blower Door Testing - Field inspection data only

- Air Changes Per Hour – .21
- Average Pan Pressure – .28

ANALYSIS SUMMARY – City of North Las Vegas

Sample size

- Plan Check - 39
- Field Inspection – 8

Documentation

- Energy Code Compliance Documentation Submitted 50% of the sample structures
- R-Values Shown on Plans of 50% of structures
- NO U-Factors were shown on plans

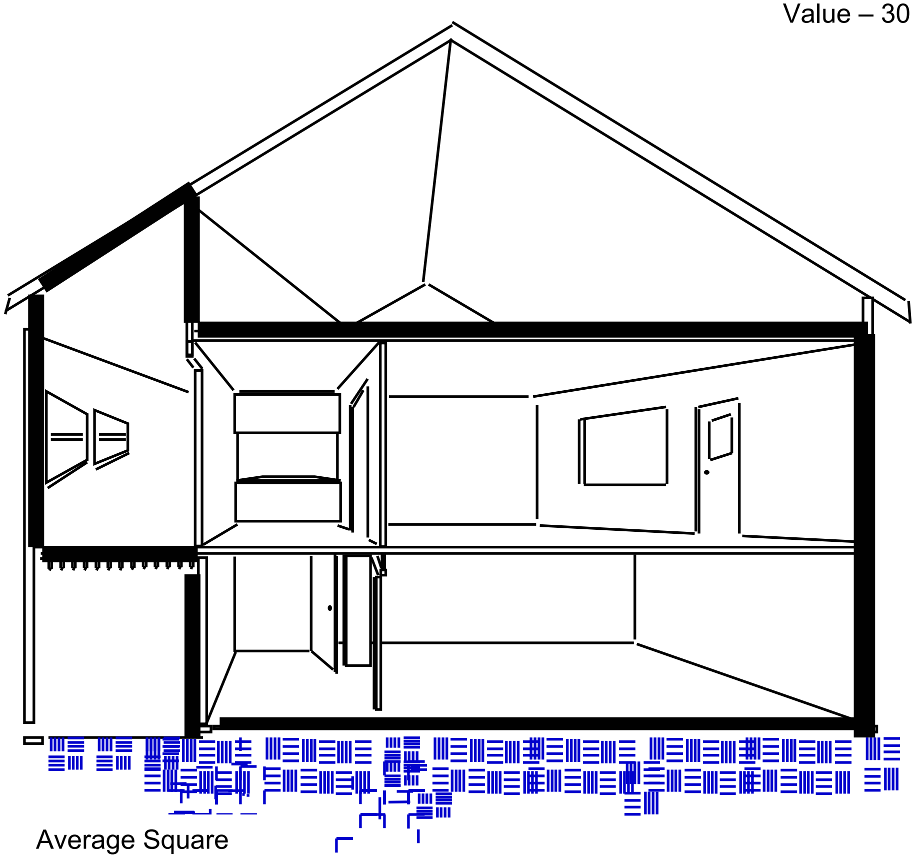
Pass/Fail of Each Code edition

ALL Field Inspected structures surveyed in City of North Las Vegas complied with the IECC for each of the code editions 1992-2000.

Summary of Findings – City of North Las Vegas
Based on field inspections – 8 Houses

Primary Roof: All Wood
Rafter/Joist Truss – 87.5%

Average Ceiling Insulation R-Value – 30



Average Glazing
Square Footage-203

Average Glazing:Wall
Area Ratio-11.53%

Typical Glazing – Metal
Framed 100%

Typical Entrance Door –
Steel - Hollow 62.5%

Average Square
Footage: 1460

Primary Walls: Wood
Frame, 16" o.c. – 100%

Average Wall Insulation
R-Value – 15.47

Typical Heating System- Gas
Heating 100%
Average AFUE- 80%

Typical Cooling System- Air
Cooled Air 100%
Average SEER- 10

Foundation: Slab – 100%

Average Insulation
R-Value – 0

<u>Average MecCheck Results</u>

1992 MEC 11.34%
1993 MEC 9.85%
1995 MEC 8.99%
1998 IECC 8.99%
2000 IECC 8.99%

Foundation Systems

- Primary Foundation Type – All Structures surveyed had slab foundations
- Primary Foundation Average Linear Ft. – 159
- Primary Foundation R-Value – No structures surveyed had insulated slabs.
- Secondary Foundation Information

2 Homes had secondary foundations.

Secondary Foundation Type	Secondary Foundation Area/Linear Ft	Secondary Foundation R-Value	Secondary Foundation Insulation Type
Crawlspace Insul Floor	512	19	Cavity
Crawlspace Insul Floor	231	19	Cavity

Plan Check average insulation for Crawlspace insulated floors was 16.89

Wall Information

- Primary Wall
  - Type –all walls are 16" o.c. Wood studs
  - Area – 1595 Square Feet
  - Weighted Average of Insulation R-Value – plan check 13.7, field inspection 15.5
- Secondary Walls – 8 Structures had secondary wall systems, typically between the garage and house.
  - Type –all walls are 16" o.c. Wood studs
  - Area – 193 Square Feet
  - Weighted Average of Insulation R-Value – plan check 11.7, field inspection14.7
- Tertiary Walls – No Structures in the North Las Vegas field inspections had tertiary wall systems

Roof Information

- Primary Roof
  - Type – 7 of 8 primary roof structures in the Southern Nevada Sample Set were All Wood Joist Rafter Truss Systems, 1 was an Oversized Joist system.
  - Average Area – 1355 Square Feet
  - Weighted Average of Insulation R-Value – plan check and field inspection roofs were all R-30
  -
- Secondary Roof Information – No structures in the Southern Nevada sample had Secondary Roof Systems

Window/Skylight Information

- Primary Window - All windows surveyed were aluminum framed, double paned.
    - Average Square Feet Glazing Area– plan check 189, field inspection 175
    - Weighted Average U- Factor – plan check .84, field inspection .78
    - Default U-factor used? – The default U-factor of .50 was not used
    - Weighted average SHCG - .60

- Secondary Windows – 7 of 8 Structures had secondary window systems
    - Average Square Feet Glazing Area– plan check 60, field inspection 30
    - Weighted Average U- Factor – .plan check .71, field inspection .65
    - Default U-factor used? – the default U-factor of .50 was not used
    - Weighted average SHCG - .59

- Skylight – No skylights were recorded in North Las Vegas

Door Information – Field Inspection Data Only

- Main Entrance Door

Main Entrance Door - Type	
Steel foam core	25%
Steel hollow	63%
Solid core flush	12%

-
    - Average Area – 22.5 Square feet
    - Weighted Average U-Factor - .5
    - Default U-factor used was not used.
    - No Storm Doors were reported

- Garage/House Door
    - Type – All House/Garage Doors were Solid Core Flush
    - Average Area – 18 Square feet
    - Weighted Average U-Factor - .36
    - Default U-factor was not used
    - No Storm Doors were reported

- Other Exterior Door – No doors of this category were found in North Las Vegas

Duct Information– Field Inspection Data Only

- Return Duct
  - Location – All of the return duct systems were in the attic.
  - Material Type – All were constructed of flex type ducting
  - Sealant – Distribution of sealant use is as follows:

Sealant Use	
Return Duct Sealant UL181 Tape	75%
Return Duct Sealant Mastic	50%
Return Duct Sealant Mastic+Tape	50%
Return Duct Sealant Duct Tape	0%
Return Duct Sealant Zip Ties	0%
Return Duct Sealant Screws	0%

  - Insulation R-Value – All flex type ducts had an insulation level of 4.2.

- Supply Duct
  - Location – All of the return duct systems were in the attic
  - Material Type – All were constructed of flex type ducting
  - Sealant – Distribution of sealant use is as follows:

Sealant Use	
Supply Duct Sealant UL181 Tape	75%
Supply Duct Sealant Mastic	50%
Supply Duct Sealant Mastic+Tape	50%
Supply Duct Sealant Duct Tape	0%
Supply Duct Sealant Zip Ties	0%
Supply Duct Sealant Screws	0%

  - Insulation R-Value- All flex type ducts had an insulation level of 4.2.

Mechanical System– Field Inspection Data Only

- Heating System
  - Heating System Type – All structures had Gas Furnaces
  - Efficiency – All systems had an AFUE of 80
  - Default AFUE was not used.
  - No secondary systems were reported

- Cooling System -
    - 100% of Structures had Air Conditioning – all were Air Cooled Air Systems.
    - Efficiency – Each had a SEER of 10
    - Efficiency Default of 10 was not used

    - No secondary systems were reported

Blower Door Testing– Field Inspection Data Only

- Air Changes Per Hour – .19
- Average Pan Pressure – .39

APPENDIX III
PROJECT PROCEEDURES

Selection of Data Analysis Tool

The U.S. Department of Energy's MEC*check* energy code compliance tool was selected as the data analysis tool for the study. MEC*check* was selected because it is the most widely used energy code compliance software in the market, provided a method of analyzing a large population of buildings in a cost effective manor and provided consistent results. The analysis for all code editions could be done with one building input into the software. One of the goals of the study was to determine the rate of compliance with various versions of the energy code, which the software was able to accomplish. The software also allowed the ability to model high efficiency heating and cooling equipment, which are typical trade-offs.

Development of Data Collection Tool

A data collection form was developed for use with the plan review portion of the study and that could be taken into the field to confirm energy efficiency values noted on the plans. The input screens from the MEC*check* software were used as a basis for the form. This allowed easy input from the form to the software during the data analysis portion of the study.

The number of assembly types in a typical home was also considered during the form development. It was important that space was provided to record as many assembly types per home as possible. For example, homes could have both a vented attic and a cathedral ceiling formed by rafters. Residential construction with vaulted ceilings and an attached garage would have exterior walls (wall between the conditioned space and the outside), attic kneewalls (between the conditioned space and attic) and a wall between the house and the unconditioned garage.

The survey instrument was developed using Microsoft Excel. Using Excel for the development of the instrument allowed the data collection staff to complete the form on laptop computers and than email them to the computer where the data analysis occurred. However, the experience of this project was that the data collectors typically printed out the forms and completed them by hand.

Once a draft of the form was completed, it was sent out for review and comment to those Nevada Power/Sierra Pacific staff and contract staff responsible for data collection. It was important to solicit review of the form by those that would be using the tool in the field to ensure that the form would not be a barrier to completing the study. Once the comments were collected, the forms were revised and sent out to the data collection staff. A copy of the data collection tool is included in Appendix IV.

Development of Access Data Base

Microsoft Access software was used as the database for the project. Access was selected because of its ability to store and query data for the project. This project utilized most of the capabilities within Access for analyzing the data. A link was established with Microsoft Excel to generate a portion of the averages used in the reporting and to generate other numbers needed in the report. Given the quantity and variation of data collected within this study, the combination of Access and Excel provided project researchers with all the necessary data management capabilities.

Data Collection Team

The data collection team was selected during the drafting of the initial U.S. DOE Codes and Standards grant proposal. The primary responsibility of the teams were to conduct the initial plan reviews at each of the selected jurisdictions and then contact the builders to arrange for the on site inspections. Contractors and Nevada Power/Sierra Pacific staff were selected in Northern and Southern Nevada for several reasons. Past knowledge and an existing working relationship with the builders was an important consideration to ensure that the teams could get the builders cooperation in the study. The second reason was that it would be easier to schedule the on-site inspections if the team were located in the area versus having to travel. The team could schedule an on site inspection on shorter notice if the house became available to test. Finally, travel costs could be kept to a minimum if the team were located in the area.

The contractors that were selected for the study were certified energy raters working under the Energy Rated Homes of Nevada program. They were selected because of their experience in blower door testing, residential energy usage and prior builder contact. Jim Taylor was selected in Northern Nevada and Michael Berry in Southern Nevada. The initial Nevada Power/Sierra Pacific staff selected to participate in the project also had experience in testing of homes, but more importantly, had prior contact with several of the builders located in Southern Nevada through past utility programs. Eric Makela also served on the data collection team for Northern Nevada focusing primarily on the plan review portions of the study and participated in on site inspections.

In addition to Eric Makela, Mike Berry, and Jim Taylor, other members of the data collection team included Larry Burton of Sierra Pacific Power Company and Nevada Power, and Gary Yates, student intern to Nevada Power Company.

Selection of Participants

Jurisdictions in Northern and Southern Nevada were selected to participate in the study. The largest population center in Northern Nevada is the Reno metropolitan area. In Southern Nevada, the Las Vegas metropolitan area is the primary population center. A sample size of 200 single-family buildings was selected to represent housing starts in Nevada. Based on residential permit activity 70% (140 homes) of the sample was drawn from Southern Nevada and 30% (60 houses) from Northern Nevada.

Northern Nevada

The following jurisdictions were selected for the study in Northern Nevada:
- City of Reno
- City of Sparks
- Washoe County
- Carson City
- Lyon County

These jurisdictions had the greatest number of housing starts and represented all of the jurisdictions within the Reno Metropolitan area. Each of these jurisdictions was contacted to invite their participation in the study (see Notification and Scheduling of Jurisdictions).

Southern Nevada

The U.S. DOE Special Projects Codes and Standards grant proposal referenced 5 jurisdictions in Southern Nevada that were selected for the study:
- City of Las Vegas
- City of Henderson
- City of North Las Vegas
- Clark County
- City of Mesquite

Of the jurisdictions that were selected, only three participated in the study. The city of Las Vegas selected not to participate due to manpower constraints. The City of Mesquite was not contacted because it was not in the Nevada Power Service territory, one of the grant project partners.

Notification and Scheduling of Jurisdictions

Once the jurisdictions were selected for the study, letters were distributed to the Building Officials to invite their participation. The letter provided an explanation of the goals and objectives of the residential baseline study, the expectations for each jurisdiction wishing to participate, and the incentive for participating in the study, i.e. one free day of energy code training. A copy of the letter is in Appendix IV. Letters were sent to all of the jurisdictions referenced above with the exception of the City of Las Vegas and City of Mesquite.

A meeting was held between Jess Traver, the building official for Washoe County, Bob Jones, Executive Director of the Builders Association of Northern Nevada, Dave McNeil, NSOE (project grantee) and Eric Makela, ICBO (project sub-grantee). The purpose of the meeting was to discuss the study and the potential upgrade of the current energy code in Washoe County. The home builders association pledged support for the study.

ICBO staff conducted follow-up phone calls to each of the jurisdictions after each of the letters were sent out. In some cases, it was difficult to contact the jurisdictions due to bad phone numbers in the ICBO jurisdiction database. A follow-up letter was then sent to the Cities of Henderson, North Las Vegas, Las Vegas and Clark County. The follow-up letter was sent because of a delay in getting the data collection team in the field due to manpower constraints with Nevada Power. Because of the follow-up letter, the city of Las Vegas decided to not participate in the project due to manpower constraints. Several conversations were had with representatives of the jurisdiction but the result was their withdrawal from the project.

Ultimately only the cities of Henderson and North Las Vegas and Clark County participated in the study in Southern Nevada. The City of Mesquite was removed from the list because it was not within the Nevada Power Service Territory and therefore on-site field inspection work could not be supported by the utilities cost share.

Training of Data Collection Team Members

To ensure consistency in the data collection process, a training was held for all of the data collection team members. Those in attendance included staff from the Nevada State Energy Office, Nevada Power/Sierra Pacific and contractors Jim Taylor and Michael Berry. The training was held at the Nevada Power facilities in Las Vegas, NV, in December, 2000. The 2-day team training consisted of a ½-day overview of the residential provisions of the Model Energy Code/International Energy Conservation Code. This training was provided to ensure that the project staff had a background on the code provisions. An existing ICBO energy codes presentation was modified for use during the training.

The second half of the day was focused on how to complete the data collection form. A presentation was developed to assist in instructing the staff on how to complete the forms. Copies of the presentation materials were provided to each of the attendees. Comments were also solicited to modify the data collection form so that it would better work in the field.

Day two of the training was held in the field at a house under construction but near completion. The purpose of the training was to acquaint the data collection staff on how to set up a blower door and pressure pan for use in collecting air tightness data in the field. Nevada Power staff conducted the training session. The second portion of the training focused on how to conduct energy code data collection in the field. ICBO staff conducted this part of the training and set expectations for the data collection.

Selection of Residential Projects within Jurisdictions

The number of residential buildings that each jurisdiction selected was based on the location of the jurisdiction (Northern or Southern Nevada) and representing a cross-section of typical “mass-production” home building in each location. For Northern Nevada, each jurisdiction was requested to select 12 "typical" homes to complete the sample. The original sample for jurisdictions for Southern Nevada assumed that each jurisdiction would select 28 "typical" homes. Once it was determined that the City of Mesquite would not be included in the project, the number of plan reviews were increased to 35 per jurisdiction to ensure the original sample size would be maintained. Then, after the City of Las Vegas elected to not participate, it was decided that the number of plan reviews should remain at 35 for the remaining jurisdictions. Increasing the number of plan reviews would have placed a significant burden on the remaining jurisdictions. The team decided to wait on making a determination on how to collect the additional 35 homes to complete the sample size.

The study was structured to allow each jurisdiction to select their sample based on what they felt was typical residential construction. One of the home selection parameters was that no more than three model types were to be selected from a single subdivision. This helped to distribute the sample across several builders within the jurisdiction. Most of the homes selected were from subdivision tract developments, which is common construction practice in the sample areas. The jurisdictions were also asked to select projects were they thought that the builders would be cooperative.

A decision was made to let the jurisdiction select the sample prior to contacting the builder instead of contacting the builder first to determine if they wanted to participate in the study. The advantage to this approach was that the sample would be more objective if the jurisdictions selected the sample. It was felt that builders might self-select to not participate in the study or select favored plans and homes to be inspected by the project team, leaving a sample that would be incomplete and/or not representative of the population of "typical" home construction. The disadvantage of this approach was that there was no guarantee that the builder would participate in study even though their project was selected by the jurisdiction.

Plan Review Data Collection

The plan review for the jurisdictions was typically conducted by one of the team members. A time was scheduled to visit each of the jurisdictions to conduct the plan review. The jurisdiction provided to space to work and selected the number and type of plans per the instructions in the initial letter that was sent out. The jurisdictions were to select the plans prior to the team member's arrival at the building department office so that there was not influence on the selection process. Typically however, the jurisdictions waited until the arrival of the team member to ensure that the plans that they were selecting would work for the study.

The data collection form was used to record the data from the building plans. It was important to establish a level of consistency in the way that the forms were completed, the data collected and the terminology that was used to identify different features within the building. Because data was going to be collected in Northern Nevada first, one of the Southern Nevada team members joined in the plan review process for the City of Reno. This joint effort worked well to train the team member and answer any questions that arose as part of the process.

Tract Development

One of the most significant issues that needed to be addressed was how to accurately document houses in tract developments that may include several variations to the same floor plan. Each model type for a development had several variations that included window placement and size, room arrangements, garage placement and bonus rooms over garages. For example a Model 1775 house may have a base set of building plans that show the house to be three-bedrooms with a den. Option A of this plan might include a bonus room over the garage. Option B of this plan might include a forth bedroom instead of the den and have an increase in window area. Finally, Option C might include two sliding glass doors in the family room instead of smaller windows. The actual built home might be a combination of the various options. Given these options it was critical to document all of the assumptions on the data collection form for the options that were documented. The data collection staff spent time capturing this information so that when the on-site visits were conducted they could collect accurate data based on the model selected.

In general, there were fewer options in the tract development in Northern Nevada than in Southern Nevada. This was due to the smaller track sizes in Northern Nevada, the lower cost of some of the homes in the tract development and fewer number of model types per tract development.

Information relevant to demonstrating compliance with the energy code was collected from the building plans. This included insulation R-value data in addition to glazing U-factor and area. Assumptions for insulation R-values and the types of glazing were made if there was not enough information on the building plans. The assumptions were based on typical construction practice in the region. This information was provided to the field inspection team to verify during the on site inspection. Area take-offs were conducted to determine the area of each piece of the building envelope. This included wall, roof, floor and glazing area.

Additional information was also collected on the non-insulation and glazing-dependent portions of the energy code. These are considered basic requirements and include elements such as air sealing, vapor retarders, duct sealing and insulation levels, etc. Variation of many of these items happen in the field but the code requires that conservation features used to demonstrate compliance with the code be included in the plans and documentation. Each of the jurisdictions had variations on the level of detail to be submitted for plan review and the type of plans that they considered a minimum submittal. For example, a portion of the jurisdictions required a floor plan, elevations, and structural details and no information on the mechanical system. Other jurisdictions required a complete set of plans that included architectural, structural, electrical, mechanical, and plumbing plans. There was some consistency between jurisdictions within a region but not between Northern and Southern Nevada.

If energy code compliance documentation was submitted with the building plans, the plan review team verified that what was shown on the documentation was included on the plans. The primary area that was checked was the area of each assembly. For example, the glazing and wall area were checked against what was used to show compliance on the documentation. The insulation R-values and glazing U-factors included on the compliance documentation were recorded if the values were greater than what was shown on the building plans. A builder would need to meet the values documented in the compliance documentation to comply with the code.

Each of the jurisdictions was very cooperative with the staff working to collect the data. Either a conference room or open work station was provided in each jurisdiction to perform the work. On average, the time allowed for plan review for each set of plans ranged from 45 minutes to 1 hour depending on the complexity of the building and the type of information presented on the building plans. Time was also spent during the plan review stage to discuss the study with the building official and plan review and inspection staff. This allowed them the opportunity to ask questions and provide comment. Time was also taken to discuss the jurisdiction’s plans for the possible adoption of the ICC International Codes including the International Energy Conservation Code.

A portion of the form required the collection of contact information for the builder. The information collected included contact name and phone number of the builder and any other information that would be useful in contacting the builder to schedule the on site inspection.

Field Inspection

Once the plan review was completed for each of the jurisdictions, the next step in the process was to contact the builder associated with the project to set up the visit to the site for the inspection and blower door testing. Two teams worked in Nevada. Jim Taylor lead the field team for Northern Nevada with staff from Nevada Power/Sierra Pacific Power or Eric Makela assisting when needed. The description that follows describes separately, the steps taken in Northern Nevada and Southern Nevada to collect the on site data.

Northern Nevada

Contacting the Builder

The contact information that was collected during the plan review portion of the study was used to make contact with the builder. This data was typically recorded from the submittal for each building permit. All contacts with the builder were made via telephone calls. Several problems resulted in making contact with each of the selected builders. Many that were selected did not return the phone calls, forcing Jim Taylor to make several calls to the same builder. A portion of the builders, once contacted, were suspicious of the intent of the study as they viewed this as more of a builder-specific audit (with possible repercussions) than the intended industry baseline data collection. In addition, projects submitted under one builder were often sold to another builder, located out of the state, making contact more difficult. Some of the homes that were selected were in an early stage of construction with the completion data over a month away. A few of the projects were already completed with occupants in the homes and no new plans to build additional units. In still another instance, during the course of setting up on-site visits, it was learned that one of the plan-reviewed subdivision projects was facing the potential for homeowner defect litigation. It was decided to drop these homes from the study sample and select replacements.

The field collection team occasionally selected additional homes while in the field to make up for the homes that were lost from the sample. Data collection forms were completed in the field for each of the additional homes. This required the survey team to do area take-offs in the field to collect the pertinent information. Once the data was collected in the field, arrangements were made to re-visit the jurisdictions and pull the corresponding building plans. Eighteen new homes were selected in Lyon County, Sparks, Carson City, Washoe County and Reno in this manner.

Once the on-site inspection was scheduled, typically a two-person team visited the site. Because a blower door and pressure pan test was to be conducted on each home it was critical that the testing be conducted in homes that were close to calling for the final inspection. Testing was usually conducted in a model home within a subdivision unless the home that was selected met the required criteria.

The on-site inspection consisted of two elements. The first element focused on collecting data to determine code compliance. The second element focused on testing envelope and duct air leakage. The two-person teams were able to work efficiently at each of the homes. One person was responsible for setting up the blower door while the other person verified the information on the data collection form.

Code Compliance Data Collection

Several items needed to verified on the data collection form, as one of the goals of the study was to determine if the building, as built in the field, complied with the energy code. Another goal was to determine if the building plans matched the built home. Glazing area and the number of windows in the home were compared with the data collection form. Glazing U-factor was also verified if NFRC labels were on the windows. Insulation R-values were also checked. Often times insulation levels were difficult to verify if the tested home was sheetrocked. By selecting residential construction within tract developments, the data collection team was able to locate the same model type within the development that had exposed insulation and other efficiency measures that needed to be verified. Information was collected on duct sealing methods and duct insulation R-values. HVAC equipment efficiency was also collected on site. Some of the items collected during the plan review stage were not verified in the field unless there was a note on the inspection form to do so. The square footage of different parts of the building envelope was typically not verified. This included exterior wall area, roof/ceiling area and crawlspace wall area. These items typically are not changed between the plans and the built structure. However, a spot check was done on the volume of the home to ensure that the wall plate heights were reasonable based on the plans and that there were no vaulted ceilings.

Blower Door/Pressure Pan Testing

While one of the team members conducted the energy code data collection the other team member set up the blower door to test the home for air leakage.

Both members of the team participated in the pressure pan testing. In most cases, the builder provided a completed model home for the blower door testing and then allowed access to the building sites for the additional data collection. This was essential because data on insulation, glazing efficiency, air sealing, etc. could not be collected at the model. The teams were able to work effectively within the time budgeted for each of the inspections.

In several cases, the builder or site superintendent participated in the blower door testing. This presented an opportunity to educate the builder on typical sources of air leakage within the home and how to prevent them. Field inspection staff from the jurisdiction also participated in a few of the site visits.

Southern Nevada

The data collection process in Southern Nevada was designed to be conducted in a similar manner as that in Northern Nevada. Once the building plans were reviewed during the plan review portion of the study, the contact information was used in an attempt to contact the builders. As compared to builder-contact experience Northern Nevada, there was significantly greater difficulty experienced in the process of making contact with those that could give permission to go out on site to collect data. Typically, several calls were made to the builder to solicit permission to go on-site. There was difficulty in making initial contact and often times, those that were contacted did not have the authorization to grant permission. If contact was made, the builder was reluctant to allow the on-site inspection. Manpower constraints were given as one reason. As compared to Northern Nevada, there was a higher level of suspicion among builders as some were worried about construction defect litigation and that our data collection process might lead toward potential claims. A letter was drafted that provided details about the data collection effort and that stressed the on-site findings would be reported anonymously to protect the privacy of the builder and the project. This letter was faxed to the contacted builders who requested more information.

Assistance was also requested from jurisdictional staff in Southern Nevada to gain access to the construction sites. It was hoped that they could contact the builder and try to gain access to the projects. This proved unsuccessful due to manpower constraints within the jurisdictions. On the advice from one of the plan reviewers, the Southern Nevada Home Builders Association (SNHBA) was contacted to determine if they could be of assistance. After considering our request for assistance, staff from the SNHBA recommended that we attend their Codes Advisory Committee meeting to discuss the study and request their cooperation. The meeting, held on April 10, 2002, was attended by representatives of several jurisdictions in Southern Nevada, and several builders appointed to the committee. An overview of the study was presented by Eric Makela to those that attended the meeting. There was little discussion following the presentation and very few questions from the attendees, and virtually no offers of cooperation from attendees, except from Pulte Homes. Because of these difficulties in Southern Nevada, very few on site inspections were conducted using the original sample selected from the jurisdictions. Only 13 on site inspections were conducted on the 102 plan reviews selected for the study.

To address this situation, a meeting was held in November, 2002 between representatives of Nevada Power, Sierra Pacific Power, Jim Taylor, Michael Berry, Larry Burton (a data collection contractor hired by Nevada Power/Sierra Pacific Power), NSEO and ICBO to look at options for completing the on site inspections in Southern Nevada. Several options were placed on the table during the meeting. It was decided that it was no longer cost effective to continue to try to contact the builders to gain access to the sites. It was decided that continuing on this course would only spend the allocated budget without the guarantee of gaining access to the building sites. The decision was made to take a different course in meeting the goals of the project.

Replacement Residential Projects

Woods & Associates (W&A) was contacted in Southern Nevada to determine if they could provide data on a population of houses. W&A is one of the leading providers of energy code compliance documentation and Energy Star certification in Southern Nevada with a large client base that represents both homes built to the code and those that are built to U.S. EPA Energy Star standards. The consulting firm also provides blower door testing for many of their clients. Based on projections within the Southern Nevada market place it was decided that 50% of the population of houses provided would be Energy Star certified and 50% would be of standard construction representative of the region. Data for 100 homes would be provided under the terms of a contract agreement. It was also important that the data represent a mix of builders and developments to try to maintain the grant project's a representative sample.

Jurisdiction Training

One free day of energy code related training was provided to those jurisdictions that participated in the project study. There were no requirements placed on the type of training that the jurisdictions could request other than it needed to be on the energy codes. For example, either training on the residential energy code or the commercial energy code could be delivered. Plan review and/or inspection training was also offered as possibilities. Where possible, the jurisdictions were encouraged to select training on more current codes (i.e. the 1995 Model Energy Code or more current). It was hoped that by being exposed to a more current energy code and the compliance tools that were associated with it, that it might start discussion on the possible adoption of a newer code.

Training for Northern Nevada

Mike McCullogh, the chief plans examiner for Washoe County, coordinated plans examiner training for jurisdictions in the Reno Metropolitan area. The City of Reno is currently enforcing the 1995 MEC and Washoe County was proposing to adopt the 1995 MEC in the summer of 2002. (Note: this adoption was postponed for one year and will now be adopted in the summer of 2003). All jurisdictions that were included in the study in Northern Nevada were invited to the training sessions. The three days of training, held on May 1 – 3, 2002 included two days of residential training and one day of COMcheck-EZ training. The two one-day residential training sessions were identical to allow the jurisdictions to send a portion of their staff each day.

The training materials for the two one-day 1995 Model Energy Code classes were based on an existing course focused on the 2000 International Energy Conservation Code, utilized by ICBO instructors, and modified to reflect the provisions within the 1995 MEC. A Power Point presentation and handout materials were developed for the training session. The session covered the following topics:

- Introduction to the MEC
- Scope and Application of the MEC
- Basic Requirements
- Insulation and Window Compliance Options
    - Chapter 4 Overview
    - Chapter 5 Compliance Approaches
- Overview of the MECcheck Compliance Approach

Digital stills of problem areas associated with energy code compliance were incorporated into the presentation. The shots were taken during the on site data collection part of the project. Twenty-three participants attended the residential training sessions including representatives from the following jurisdictions:

- Washoe County – 10 participants
- City of Reno – 1 participant
- City of Sparks – 3 participants
- Carson City – 2 participants

In addition to the jurisdictional staff, others in attendance included mechanical contractors and builders (7 participants total). Copies of the presentation materials were provided to each class participant during the training. As a follow-up to the MEC training, the provisions within the new 2001 Supplement to the International Energy Conservation Code that addressed sunspace additions was forwarded to the Washoe County for their review and possible adoption.

One of the code compliance issues that was addressed during the training focused on insulating the crawlspace walls and ventilating the crawlspace. For most jurisdictions in Northern Nevada this insulation, practice is typically allowed, primarily for freeze protection. It was communicated that if insulation is placed on the crawlspace wall and credit is to be taken under the energy code, the code will not allow the crawlspace to communicate with the outside air. This is in direct conflict with the 1997 Uniform Building Code, which is enforced in Northern Nevada. The City of Reno has mandated that all insulation for houses built over crawlspaces be placed in the raised floor.

The third-day of training consisted of a one-day session of complying with the ASHRAE 90.1-1989 code (referenced in 1995 MEC) using the U.S. DOE COM*check-EZ* compliance tool. Existing training materials based on COMcheck-EZ were used in the training sessions. The course covered the following topics:

- Introduction to COMcheck-EZ
- Scope and Application
- Building Envelope Requirements
- Mechanical System Requirements
- Lighting System Requirements

The one-day COMcheck-EZ training session was attended by 13 participants that represented the following jurisdictions:

- Washoe County – 3 participants
- City of Reno – 1 participant
- City of Sparks – 2 participants
- Carson City – 1 participant

Two HVAC companies also attended (6 participants total). Currently on the City of Reno requires COM*check-EZ* compliance reports and several questions were asked from the representative of Reno during the training session. Copies of the presentation were provided for each of the attendees.

Field Inspection Training

An additional training session was offered to the Northern Nevada jurisdictions due to unspent funds within the grant. The training session was focused on how to field inspect for the residential provisions of the 1995 MEC. The class was designed to be conducted at a building site with the assumption that inspectors best learn when they can be shown what to inspect on the job site, versus in the classroom.

The objective of the course is to provide guidance on the energy code features to look for at each inspection (i.e. foundation, framing, insulation, and final inspection). The course was conducted at a residential tract development so that several phases of a project can be viewed at one site. The CABO 1995 Model Energy Code was used as the basis for the course as this is the adopted code by the city of Reno and soon to be adopted by Washoe County. The concepts that were presented will be relevant to inspection for all residential energy codes.

The course covered the proper installation of energy features to comply with the code and discussed building science reasons behind the provisions. A blower door test was conducted as part of the session to educate the participants on air transfer due to infiltration through the envelope and possible consequences that this can have on the house.

The course covered inspection for the following energy features during different phases of construction:

Foundation Inspection

- Slab edge insulation for Slab-on-grade foundations (If possible)
- Crawlspace wall insulation (for non-vented crawlspaces)
- Ductwork located in the crawlspace (air sealing and insulation)

Framing Inspection

- Verify glazing U-factor and area
- Verify ductwork insulation and air sealing requirements for ducts located in attic and exterior walls
- Verify HVAC efficiency if credit is taken for high efficiency equipment
- Verify air sealing for holes and penetrations in the building envelope.
- Verify IC rated and air tight recessed can lights are installed

Insulation Inspection

- Verify properly installed wall insulation
- Verify that floor insulation has been properly installed if required
- Verify that insulation has been installed in the floor over garage and any cantilevered floors.
- Verify the installation and placement of a vapor retarder
- Verify any additional air sealing (e.g. attic kneewalls)
- Verify the installation of attic markers for blown in insulation and baffles at the eave vents.
- Verify cathedral ceiling insulation

Final Inspection

- Verify correctly installed attic insulation (either blown in or batts)
- Verify installation of thermostat
- Verify condensing unit piping insulation
- Verify piping insulation and pump control requirements for circulation water heating systems
- Perform blower door testing to determine air leakage
- Perform pressure pan test on the duct runs

An inspection checklist was provided for each of the participants in addition to Power Point handout materials covering information on what to look for during each inspection. Forty participants attended the two half-day sessions. The following jurisdictions were represented at the training:

- Washoe County – 5 participants
- City of Reno – 12 participant
- City of Sparks – 9 participants
- Carson City – 1 participant
- Douglas County – 4 participants

Others represented at the training included home inspectors, engineers, builders and HERS raters (9 participants total).

Training for Southern Nevada

Code Adoption Committee - Mechanical Code Review Training. During the course of the study the Mechanical Code Review Committee, representing all the jurisdictions in Southern Nevada, requested a one-day training session on the 2000 IECC. This committee is responsible for recommending the adoption of energy codes in Southern Nevada and was considering the 2000 IECC.

A one-day training to familiarize the committee with the requirements of the residential and commercial provisions of the 2000 IECC was delivered in October, 2001. Representatives from Clark County, City of Henderson, City of North Las Vegas and the City of Las Vegas attended the training. The morning session covered the residential provisions and focused on these key areas:

- Introduction to the MEC
- Scope and Application of the MEC
- Basic Requirements
- Insulation and Window Compliance Options
    - Chapter 4 Overview
    - Chapter 5 Compliance Approaches

Overview of the MECcheck Compliance Approach

The afternoon session covered Chapter 8 of the IECC and focused on using COM*check-EZ* to demonstrate compliance with the code. The following topics were covered:

- Scope and Application
- Building Envelope Requirements
- Mechanical System Requirements
- Lighting System Requirements
- Overview of COM*check-EZ*

There were several good questions received during the overview of the residential and commercial requirements. In general, the group was not concerned about the implementation of a new residential energy code as they felt that the 2000 IECC could be adequately enforced. Instead the group had more of a concern with the potential enforcement of the ASHRAE 90.1-1989 Energy Code referenced in Chapter 7 of the ICC 2000 IECC.

Additional Plan Review and Field Inspection Overview Training.

Three days of training were conducted in Southern Nevada at the Clark County Building Department. The first two days of training, held on December 10 – 11, 2002 focused on residential energy code compliance and were developed for plan review and field inspection for the residential energy code, in particular the 1992 Model Energy Code (MEC). The training session was divided into two sessions. The morning session focused on plan review for the 1992 MEC. The Chapter 4, Chapter 5 and Chapter 6 methods of compliance were covered with actual submittals being used for Chapter 4 – Systems Performance. A report from the MICROPAS software was reviewed in addition to reports from the REMRATE software, commonly used to demonstrate compliance in Southern Nevada. Information pertinent to demonstrating compliance was highlighted for the plan reviewers to give them a better idea of what to look for on the submittals. The MICROPAS and REMRATE submittals were provided by Woods & Associates. The US DOE MECcheck software was also used as part of the training.

The afternoon session focused on field inspectors and how to inspect for compliance with the 92 MEC. The prime focus was on ensuring the mandatory requirements (i.e. air sealing, duct insulation, etc) were installed properly. In addition to a discussion on the mandatory requirements, proper installation practices were addressed in an effort to help the inspectors focus on getting the trades to correctly install conservation measures such as insulation. The US DOE video, Inspecting Residential Buildings for Compliance with the 2000 IECC was used in the training. The plan review and inspection training was repeated on day two. Twenty-two attended the first day and nineteen attended the second day of training. Jurisdictions that were represented included:

- City of North Las Vegas – 18 participants
- City of Henderson – 15 participants
- Clark County – 7 participants
- Other – State Energy Office – 1 participant

The third day of training held on December 13, 2002 focused around compliance with the commercial provisions of the 92 MEC by using the US DOE COMcheck-EZ software. The 92 MEC references ASHRAE 90.1-1989 as an alternative method which then allows the use of COMcheck-EZ to demonstrate compliance. Scope and application, envelope, mechanical system and lighting system requirements were covered in the training. The prescriptive method and software were demonstrated to those that attended. The training was relevant to the building envelope and mechanical systems but the jurisdictions in Southern Nevada currently exempt the lighting systems from the energy code. Bringing the lighting systems into compliance with current energy codes represents a high potential for energy savings in the region. Seven representatives from the City of Henderson and Clark County attended the training. Jurisdictions that were represented included:

- City of North Las Vegas – 1 participants
- City of Henderson – 3 participants
- Clark County – 3 participants

Appendix IV

A. Data Collection Tool
B. Data Collection Training Materials
C. Jurisdiction Letter
D. Northern Nevada Residential Training Materials
E. Northern Nevada Commercial Training Materials – COM*check*
F. Overview Training of the IECC Training Materials
G. Southern Nevada Plan Review Training Materials
H. Southern Nevada Inspector Training Materials
I. Northern Nevada Field Inspection Training Materials
J. Electronic Copies of Training Materials

Appendix V

A. Electronic Files
    1. Data Base
    2. MEC*check* Analysis Input Files
    3. Digital Stills

APPENDIX IV
TRAINING AND SUPPORT MATERIALS

Training materials developed for, and used in this project are bound under separate cover, entitled Appendix IV. Training and Support Materials, In-Field Residential Energy Code Compliance Assessment and Training Project.