INCREASING ENERGY EFFICIENCY IN NEW BUILDINGS IN THE SOUTHWEST

Energy Codes and Best Practices

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Saving Money and Reducing Pollution through Energy Conservation

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Energy Codes and Best Practices

by

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Prepared for

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The authors are indebted to everyone who made suggestions and we took them all seriously. If errors remain, they are due to us, not to others. Of course, energy codes and related matters both in the Southwest and elsewhere remain large and important topics to which SWEEP intends to continue to contribute. Accordingly, all readers are urged to provide further suggestions concerning this report or related work that should to be undertaken.

All views and opinions expressed herein are those of SWEEP and do not necessarily reflect the views of funders, contributors, or reviewers.

Executive Summary

Energy code adoption and enforcement in much of the Southwest is not far advanced in comparison with many other states. Of the six states, only Utah has up-to-date residential and commercial energy codes that are mandatory statewide. Areas without strong energy codes or enforcement tend to fall into two classes: those in which a very small number of buildings are being built, such as northern New Mexico, and those in which ENERGY STAR® and other programs that promote energy efficiency are active and growing quickly, such as Phoenix. Further, in virtually all jurisdictions, there is movement to adopt better codes or, where adopted, to increase efforts to enforce codes and educate the building community as to the value of designing and building energy-efficient structures.

Energy codes can set the tone for energy efficiency, establish threshold criteria, affect the marketplace for both raw materials (e.g., windows) and finished products (buildings), and can be communicated to key actors (architects, engineers, builders). Further, supporting code implementation through education, training, and enhancing building inspection can maximize the energy savings and other benefits of up-to-date energy codes.

Codes define the minimum necessary to achieve what currently counts as adequate energy performance, but they cannot ensure that first-rate buildings result. Stronger coordination between the code community and other entities like utility and government-supported efficiency programs will create natural synergisms in achieving the most important goal: fine, very energy-efficient buildings whose lifetime costs are substantially lower than the ordinary buildings that constitute most of current building stock.

As ENERGY STAR, Building America®, and other energy efficient programs draw the public's attention to the practicality and cost effectiveness of energy efficient buildings, the new awareness of better-educated consumers promotes better quality. The response of the marketplace to a more sophisticated buying public in such fast-growing cities as Tucson and Las Vegas is remarkable. Nevertheless, there remains large potential for cost-effective savings from better energy codes and promotion of "beyond code" new buildings throughout the Southwest region.

Status of Codes and other Activities

Arizona, the most populous state in the Southwest, adds over 50,000 new dwellings to the energy grids each year. A home rule state, many jurisdictions do not have any energy codes at all, including the City of Phoenix. Tucson implemented the 2000 version of the International Energy Conservation Code (IECC 2000) in July of 2003, and a number of other smaller jurisdictions have adopted this or a similar up-to-date code. Phoenix appears to be on a course to adopt the National Fire Protection Association 5000 (NFPA

5000) code, probably by the end of 2003. The commercial component of the NFPA 5000 refers to ASHRAE Standard 90.1, as does the IECC 2000, so a wealth of documentation, training material, and software support is available. However, the NFPA 5000 references ASHRAE Standard 90.2 for its residential energy code, which is both less stringent than the IECC 2000 code and is largely without supporting user manuals, training materials, or software. Accordingly, the implementation process may be fraught with difficulty, and support tools should be developed if Phoenix and other jurisdictions adopt the NFPA code.

Arizona has over 61 ENERGY STAR certified builders and has produced 20,000 ENERGY STAR homes through July 2003, over 20% of the nation's total. In fact, Tucson's more than 50% market share for ENERGY STAR new homes leads the nation, due in large part to well-designed, effective utility programs.

Colorado is also a home rule state, so code adoption has to be accomplished piecemeal, jurisdiction by jurisdiction. The Denver metropolitan area is growing quickly, but it has out-of-date energy codes and the process of updating is delayed by the fact that most members of the Denver City Council and its Mayor were recently replaced. There is local support for both IECC codes and the NFPA 5000. Fully two dozen jurisdictions in Colorado have up-to-date international codes on the books, and more are being added. It is expected that as many as 75% of Colorado's jurisdictions will have up-to-date energy codes on the books by 2004.

The state has an active residential energy efficiency program conducted by E-Star Colorado, which trains code officials and builders and tracks the certification process for both existing and new homes. There are 30 certified ENERGY STAR builders in Colorado. Over 75% of the ENERGY STAR homes built in the state, a total of 1200, were built in the 12 months preceding July 2003, so the program is growing rapidly. On the other hand, a field study of new homes built in Fort Collins showed that many new homes fail to perform as well as they should, pointing out the need for better education and training.

Colorado's largest utility company, Xcel Energy, conducts a program that targets new commercial buildings, helping in the design process and providing financial incentives for achieving buildings whose energy performance is substantially superior to a model commercial building code.

Nevada is growing quickly, particularly in the south. The population of the Las Vegas metropolitan area has doubled to 1.5 million since 1990, and Clark County adds about 7,000 new citizens each month—and 25,000 new single-family homes each year. Although state-owned buildings must comply with ASHRAE 90.1-1999, most jurisdictions in Nevada have out-of-date versions of model energy codes on the books, predominantly the 1992 MEC. Nonetheless, there are now 41 builders that are official

ENERGY STAR partners, ten of which are now producing only ENERGY STAR homes, most of them large production builders. In the last 12 months, these builders have produced 78% of the ENERGY STAR homes in Nevada. As of July 2003, 12,100 homes have been labeled ENERGY STAR since the Nevada program's inception; of these, 61% were labeled in the 12 months preceding July 2003.

In addition to ENERGY STAR, Nevada has a very active Environments for Living program, whose builders guarantee that heating and cooling bills will be no greater than an amount specified at the initial sale of the building. Officials estimate that 4,800 Environments for Living homes will be built in Nevada in 2003, at least 50% of which will be platinum level homes designed to exceed the energy performance of MEC 1995 code levels by 50% (Davenport 2003).

New Mexico has a decade-old version of the model energy code (with state amendments), but implementation is vigorous only in the Albuquerque area, where about half of the 700 new homes in the state each month are being built. A two-year process to adopt a version of the IECC 2000 code was sidetracked in December of 2002 by code opponents and advocates of the NFPA 5000 code.

As of the summer of 2003, the status of adopting up-to-date energy codes in New Mexico was still in flux. Nonetheless, there are 15 ENERGY STAR builders in New Mexico, one of which, Artistic Homes in Albuquerque, builds only ENERGY STAR homes. Artistic has constructed 1,339 ENERGY STAR-labeled homes, 75% of which were built in the 12 months preceding July 2003.

Utah is the only state in the Southwest that has passed a mandatory statewide IECC 2000 code for all new residential and commercial buildings. Implementation of the code, which became effective in January of 2002, is largely a local matter and those involved in both training and testing estimate that code compliance was roughly 50% in the first year after the new code became effective. By way of setting a good example for the private sector, all new state buildings are being designed to use at least 25% less energy that required by the ASHRAE 90.1-99 commercial energy code.

There are 22 ENERGY STAR builders in Utah, one of which, Ence Homes, has built over 892 ENERGY STAR homes, 98% of the ENERGY STAR homes built in the state as of July 2003.

Wyoming had about 1400 new housing starts in 2000, and the state is growing slowly. The 1997 Uniform Building Code is the current statewide code, and while it references the 1995 Model Energy Code (MEC) in an appendix, the Fire Marshal's office, which has code responsibility, has yet to officially adopt the appendix. Accordingly, the code is not in effect. A new policy adopted in April 2003 directs the Fire Marshal to adopt and implement a recent energy efficiency code, such as the IECC 2000, and apply that code to all state buildings by the summer of 2003. The policy also recommends that local jurisdictions add recent versions of the model energy code to cover both residential and commercial privately-owned new buildings.

There are 11 builders active in Wyoming listed by the U.S. EPA as ENERGY STAR partners, but as of July 2003, there have been no houses labeled as ENERGY STAR homes in Wyoming.

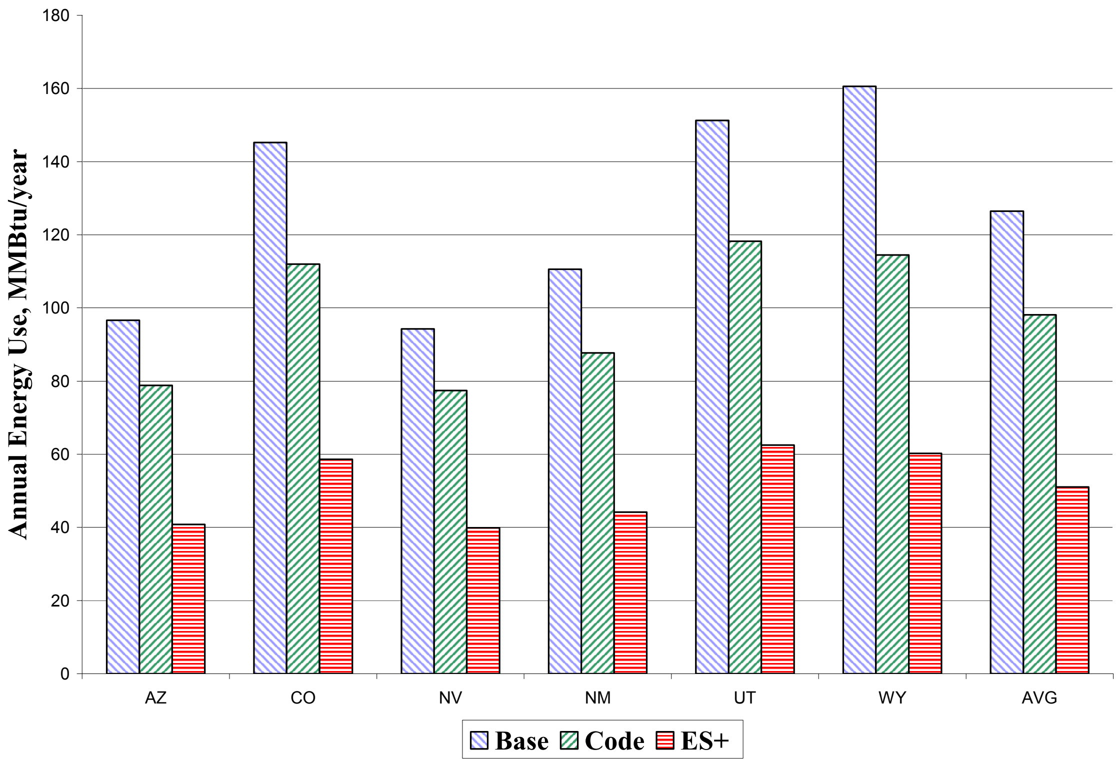
Energy Savings Potential

Analyses in this report suggest that energy savings of well over 50% above base-case structures are not only possible but are achievable very cost-effectively. More important, studies of innovative programs throughout the Southwest illustrate that a large number of efficient buildings are being built in certain jurisdictions as a result of well-designed and implemented public/private partnerships.

Residential

Toward estimating savings associated with building homes at various levels of energy efficiency, we defined and modeled two generic home types, each of 1800 square feet. In Colorado, Utah, and Wyoming, the home was built with two stories and had both a basement and crawl space. In Arizona, Nevada, and New Mexico, the home was built as a single story slab-on-grade. A number of energy-relevant characteristics of each home were varied to produce homes reflective of common practice today (base), just-meets-code (IECC 2000) and best practice (ENERGY STAR +) levels of performance in the climates of the major cities in each of the six states. The results are illustrated in Figure S-1.

Figure S-1. Annual Site Energy Use of Three Representative Homes in Six Southwestern States



In order to estimate costs and benefits of building new homes to higher levels of efficiency, three scenarios were defined which are reflective of the relative percentages of each dwelling that may be built over the periods of 2001-2010 and 2011-2020. We term these as business-as-usual (BAU), moderate improvement, and strong improvement scenarios (Table S-1). The BAU scenario assumes that minimal effort is made to expand the adoption and enforcement of energy codes or promote the construction of high-performance ENERGY STAR (and ENERGY STAR +) homes.

Table S-1. Penetration of Energy-Efficient Homes Built between 2001 and 2020 under Three Scenarios of Efficiency

Efficiency Scenario	**Base between 2001-2010**	**Code between 2001-2010**	**ES+ between 2001-2010**	**Base between 2011-2020**	**Code between 2011-2020**	**ES+ between 2011-2020**
BAU	60%	30%	10%	35%	50%	15%
Moderate	20%	65%	15%	10%	70%	20%
Strong	10%	50%	40%	5%	35%	60%

We estimate that almost 2.3 million new single-family homes (2.95 million total dwellings) will be built in the Southwest in the two decades following the millennium. These results show that if policies are pursued that result in a business-as-usual scenario, by the year 2020 the single family dwellings built between 2000 and 2020 will be consuming almost 216 trillion Btu in the Southwest. This scenario assumes that 30% of new homes built during 2001-2010 meet the IECC code and another 10% achieve Energy Star + performance, and that half of the new homes built during 2011 and 2020 will meet code and 15 percent will be beyond-code, ENERGY STAR + dwellings.

Under the moderate-improvement scenario, we assume that 65% of new homes built during 2001-2010 meet the code and another 15% are Energy Star +, and that during 2011-2020, 70% meet code and 2% achieve ENERGY STAR + performance levels. Savings in the Southwest versus BAU new housing stock of all of the new homes built in the region from 2001 through 2020 will be 12.8 trillion Btu in 2010 and 18.8 TBtu in 2020. This amounts to improvements of the moderate-improvement scenario over BAU of 11.5% in 2010 and 8.7% in 2020.

Under the strong-improvement scenario, we assume that 50% of new homes built during 2001-2010 meet code and 40% are ENERGY STAR + homes. During 2011-2020, we assume that 35% will meet code while 65% will be ENERGY STAR + homes. Savings reach 27.5 TBtu in 2010 and 62.2 TBtu in 2020. This amounts to an improvement of 24.7% over the BAU scenario in 2010 and 29.0% in 2020. The enhancement of the high over the moderate-improvement scenario is 14.9% in 2010 and 22.0% in 2020.

For residential buildings, gas savings tend to dominate over electric, especially in the second time period. Gas savings in the region average 66.2% of the total savings achieved in the moderate improvement scenario in 2010, and 72.2% of the total savings achieved in the strong improvement scenario in 2020.

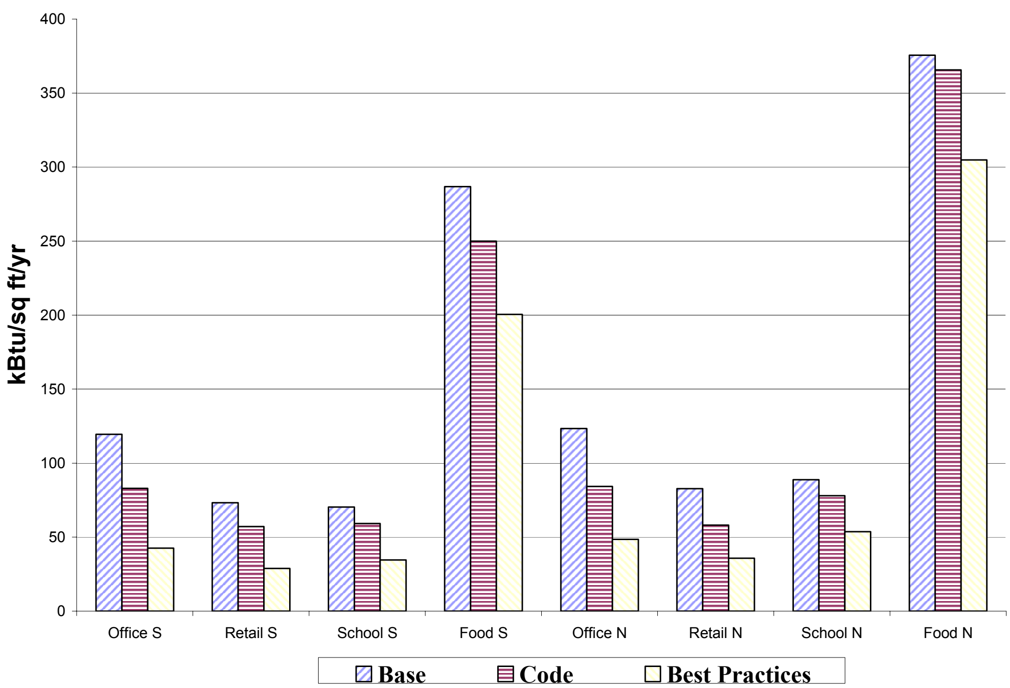
In other words, there is substantial potential to reduce energy use in new residential building through expanded adoption of up-to-date codes and promotion of "beyond code" construction techniques.

The incremental costs to build homes that just meet code versus base-case homes vary by location from $1,500 to $3,700. The incremental cost to build ENERGY STAR + homes versus base-case homes varies form $7,000 to $8,500. In spite of somewhat higher initial costs, lifetime (30-year) savings of ENERGY STAR + homes versus base homes average $17,000 under the conservative assumption that energy costs will track inflation. If energy prices outstrip inflation, conservation investments will yield even better returns.

Commercial

The commercial analysis begins by defining four generic building types that represent approximately 85% of the commercial/institutional floor area in the Southwest: an office; a retail outlet; a school; and a food services building. Similarly to the residential analysis, these buildings are modeled at three levels of energy efficiency which we term base, just-meets-code, and best practice. Figure S-2 shows the results of simulations of the relative energy intensity of these commercial buildings in the Denver and Las Vegas weather regions. The base case represents the efficiency of the average of existing commercial building stock. This is followed by a “just-meets-IECC 2000-code” case and by a case in which best current energy efficiency practices are employed in the design of new buildings.

Figure S-2. Total Energy Intensity in kBtu/square foot/year of Each Building Type for the Southern (S) States (on the left) and Northern (N) States (on the right)



As with the residential analysis, to predict energy use and savings in new commercial building construction associated with implementing codes and adopting best practices, we develop three scenarios. We call these business-as-usual (BAU), moderate-improvement and strong-improvement scenarios. Each scenario envisions different rates of implementation of code and best practices commercial and industrial buildings as shown in Table S-3. Again, the BAU scenario assumes a continuation of current policies, programs, and construction practices.

Table S-3. Penetration of Energy-Efficient Commercial Buildings Built between 2001 and 2020 under Three Scenarios of Efficiency

Efficiency Scenario	**Base between 2001-2010**	**Code between 2001-2010**	**ES+ between 2001-2010**	**Base between 2011-2020**	**Code between 2011-2020**	**ES+ between 2011-2020**
BAU	40%	50%	10%	25%	60%	15%
Moderate	20%	65%	15%	10%	70%	20%
Strong	10%	50%	40%	5%	35%	60%

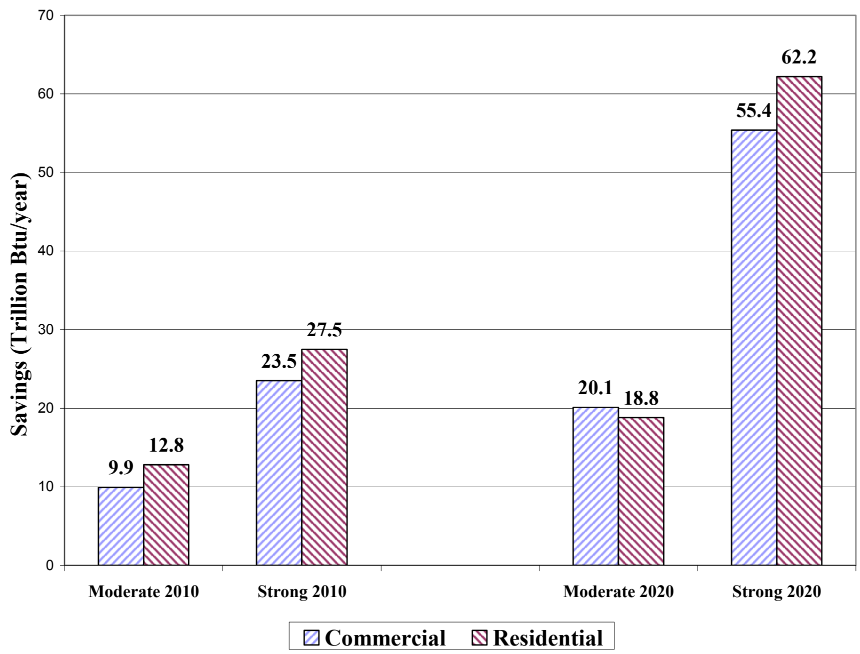
We estimate that approximately 3.1 billion square feet of new commercial buildings will be built in the Southwest in the two decades following the millennium. These results show that if policies are pursued that result in a moderate-improvement scenario, the savings versus the business-as-usual case building stock of all of the new commercial buildings constructed in the region from 2001 through 2020 will be 9.90 trillion Btu in 2010 and 20.1 TBtu in 2020. Under the strong-improvement scenario, the savings reach 23.5 TBtu in 2010 and 55.4 TBtu in 2020, 2.8 times the savings in the mid-efficiency scenario.

For commercial buildings, electricity savings tend to dominate over gas, especially in the second time period and more so in the strong improvement scenario. Electric savings in the region average 72.1 percent of the total savings achieved in the moderate improvement scenario in 2010, but fully 84.2% of the total savings achieved in the strong improvement scenario in 2020.

To put these savings figures in context, the strong improvement scenario will save the annual energy consumption equivalent of 10,800 just-meets-code moderate sized (30,000 square foot) office buildings in the region in 2010 and 25,600 office buildings in 2020.

The results of the analyses of savings of both residential and commercial buildings are illustrated in Figure S-3.

Figure S-3. Region-wide Comparison of Commercial and Residential Energy Savings Potentials under Two Scenarios of Energy Efficiency Improvement; Annual Energy Savings in 2010 and 2020 (TBtu)



The 3.1 billion square feet of projected new commercial construction in the Southwest between 2001 and 2020 corresponds to 1.7 million new 1800 square foot homes, about 25% less than the number of new single-family homes (2.3 million) projected to be constructed in the region over the same time period. Yet as illustrated in Figure S-3, under the strong-improvement scenario, residential savings opportunities are only about 10 percent greater than commercial, and in the moderate-efficiency scenario, opportunities for commercial savings slightly exceed those in residential in 2020. Thus, there is somewhat greater energy savings potential per unit of floor area in new commercial buildings compared to new homes, but the absolute savings potential is approximately equal in the two sectors.

Table S-4 shows the energy savings potential in the two scenarios of efficiency improvement broken down by state and fuel type, for both building types. It indicates that the largest electric savings potential is in Arizona, while Colorado followed by Utah offer the largest gas savings potential.

The electricity savings under the strong improvement scenario of 18,700 gigawatt hours in 2020 are equivalent to the power supply of about 3,273 megawatts of generating capacity. Thus, by following the strong improvement scenario, the region could avoid building six 550 megawatt new power plants. The savings in natural gas, 53.7 trillion Btu in 2020, is the equivalent of 60 billion cubic feet of natural gas. This in turn is equivalent to the output of 1,200 typical natural gas wells in the region.

Table S-4 also shows aggregate dollar savings in 2010 and 2020 versus the BAU scenario of the moderate and strong improvement scenarios. The dollar savings are on a net basis, meaning they are the value of the energy savings (both gas and electric) in 2010 and 2020 minus the incremental first cost for constructing more efficient new buildings in those years.

Table S-4. Combined Residential and Commercial Savings by State, Region, Fuel Type, and Millions of 2003 constant dollars in 2010 and 2020 under the Moderate and Strong Scenarios.

Moderate Improvement Scenario

State	Total Savings in 2010 (TBtu)	Total Elec Savings in 2010 (GWh)	Total Gas Savings in 2010 (TBtu)	Total Dollar Savings in 2010 (Mil $)	Total Savings in 2020 (TBtu)	Total Elec Savings in 2020 (GWh)	Total Gas Savings in 2020 (TBtu)	Total Dollar Savings in 2020 (Mil $)
AZ	7.53	1,871	1.15	42.7	14.6	3,360	3.13	155.6
CO	6.72	476	5.1	37.7	10.41	845	7.53	116.0
NV	3.56	743	1.03	6.8	6.29	1,074	2.62	56.2
NM	1.37	56	1.18	6.5	2.18	199	1.51	21.0
UT	3.31	208	2.6	20.6	4.98	351	3.77	57.0
WY	0.26	14	0.21	2.3	0.44	24	0.35	5.4
Region	22.8	3,369	11.3	116.5	38.9	5,851	18.9	411.2

Strong Improvement Scenario

State	Total Savings in 2010 (TBtu)	Total Elec Savings in 2010 (GWh)	Total Gas Savings in 2010 (TBtu)	Total Dollar Savings in 2010 (Mil $)	Total Savings in 2020 (TBtu)	Total Elec Savings in 2020 (GWh)	Total Gas Savings in 2020 (TBtu)	Total Dollar Savings in 2020 (Mil $)
AZ	16.39	4,156	2.21	98.2	40.83	9,407	8.73	432.4
CO	15.04	1,448	10.1	95.2	31.68	3,239	20.63	362.7
NV	8.72	1,960	2.03	33.8	21.22	3,948	7.75	211.3
NM	3.06	155	2.54	14.9	7.42	754	4.85	76.5
UT	7.3	600	5.25	48.2	15.37	1,307	10.91	177.7
WY	0.47	37	0.34	4.1	1.08	72	0.83	12.6
Region	51.0	8,355	22.5	294.3	117.6	18,726	53.7	1,273.1

The pattern that emerges is quite clear: the strong improvement scenario is the most cost effective and achieves the most savings of total energy, electricity, gas, and dollars. A net of about $1.3 billion is saved in the year 2020 in the strong improvement scenario, compared to about $410 million in 2020 in the moderate improvement scenario.

Furthermore, we estimate that the net savings during 2001-2020 would equal about $2.8 billion in the moderate improvement scenario and $8.4 billion in the strong improvement scenario. These estimates are conservative in that they do not reflect the energy and dollar savings that will occur after 2020 as a result of more efficient buildings constructed prior to and during 2020.

This analysis shows that for both residential and commercial buildings, there are clear economic advantages to the strong-improvement scenario which accelerates the adoption of efficiency measures over time, in large measure reflecting the greater percentage of best practice buildings being constructed. By furthering the adoption and enforcement of up-to-date building codes and expanding efforts to promote and stimulate "best practice," the Southwest region can realize significant energy and economic benefits.

Recommendations

This report urges the passing, supporting, and enforcing of up-to-date codes as well as expanding efforts to promote the construction of highly-efficient new buildings that significantly exceed minimum code requirements. This should go hand-in-hand with increasing the stringency of the codes over time as new design techniques and efficiency measures become widely accepted. Finally, we recommend expanded efforts at evaluating the actual energy savings consequences of implementing up-to-date codes and building structures to ENERGY STAR and Building America standards.

In particular, we recommend:

- **Upgrading to Up-to-Date Building Codes**. Up-to-date energy codes such as the latest version of the IECC can help states and municipalities raise energy efficiency and reduce electricity consumption and peak demand cost-effectively. Adopting a recent version of the IECC (i.e., 2000 or more recent) is especially important in the Southwest region because this model energy code has a window efficiency requirement pertaining to maximum solar heat gain coefficient (SHGC) of 0.4 for windows for warmer regions with 3,500 heating degree-days or less. This requirement, if followed, will lead to substantial cooling load reductions and thus air conditioning electricity use and peak demand savings in hotter states such as Arizona, New Mexico, and Nevada.

- **Expanding Training and Technical Assistance Efforts to Achieve High Levels of Code Compliance**. Training and assisting architects, builders, building contractors, and building code officials is critical to the successful implementation of new building codes. Such activities can significantly improve code compliance and can be very cost-effective in terms of energy savings per program dollar. Training and technical assistance is needed in a variety of areas including integrated building design, proper sizing and installation of HVAC systems, proper air tightness and insulation procedures, and the use of state-of-the-art technologies and design strategies such as daylighting, duct sealing, air infiltration reduction, indirect-direct evaporative cooling, and reflective roofing options. Compliance tools and training materials that support energy codes have been developed by a number of organizations, most significantly the Pacific Northwest National Laboratory (PNNL) which is funded by DOE. Most of PNNL's recent work has been in support of the IECC. However, if a number of jurisdictions adopt NFPA 5000, it would be appropriate to develop training materials and compliance software in support of the residential portion of the code, ASHRAE 90.2.

- **Expanding Efforts to Promote the Construction of Highly Efficient New Buildings that Exceed Minimum Code Requirements**. Through integrated design approaches as advocated in the ENERGY STAR and Building America programs, it is possible to reduce energy consumption by 30 to 50 percent relative to code requirements, and do so cost-effectively. In order to foster increased construction of highly-efficient new homes and commercial buildings, energy agencies and utilities should expand design assistance efforts, financial incentives, demonstration and promotion programs, and performance guarantees. These efforts can be modeled on the successful programs for promoting highly-efficient new homes and new commercial buildings operating throughout the U.S.

- **Raising the Performance Bar**. The history of the evolution of energy codes has followed improvements in building practices which in turn are influenced by programs such as ENERGY STAR and Building America. Raising the performance criteria for meeting ENERGY STAR and Building America minimums can have immediate positive effects in these "upper end" homes and eventually upgrade the performance of buildings at the lower end of the efficiency curve via code upgrades. The ENERGY STAR threshold is far from being unduly demanding in the Southwest, as evidenced by the large fraction of new homes qualifying in cities like Tucson, Phoenix, and Las Vegas. There is still plenty of room for improvement, particularly in this region where dry climates allow for cost-effective space cooling.

- **Evaluating Real Savings**. Good evaluation can suggest mid-course corrections that will enhance the effectiveness of the code-approval process as well as programs aimed at promoting energy efficiency. We suggest a mix of instrumentation of a small number of buildings in conjunction with a phone survey-and-bill analysis of a larger number of buildings, following up with on-site visits to both high and low outliers in search of practical wisdom. The idea is to quantify actual performance efficiently while producing rational explanations of performances that are both better and worse than expectation. We would expect the results to enlighten designers, builders and code officials. Finding out what works and what doesn't helps tailor training for all parties, makes the inspection process more pointed (and thereby efficient), and produces better buildings with fewer callbacks.

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