Commercial Building Codes: Finding the Path to Improved Compliance

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ABSTRACT

This paper presents programmatic methodologies that are achieving significant success in improving the compliance rates with building energy codes for the commercial sector. A key objective is to assist the efficiency industry in transitioning from a code support model established when codes were simple, to one that aligns with the increasing complexity of energy codes and promotes the design and construction of high performance buildings.

Building energy codes have become increasingly complex. This is especially true for the commercial building sector, where codes have rapidly transitioned from representing basic building performance at a level that no design team should go below, to mandating performance features that are on a path toward supporting high performance buildings and eventually zero net energy (ZNE) buildings. At DOE's national energy codes conference held in March 2015, there was near universal agreement on three things: the commercial energy code has become too complex for code officials to fully understand and enforce, there is no comprehensive enforcement system currently in place, and code will keep progressing toward ZNE goals. Armed with that knowledge, code developers and administrators are looking for compliance approaches that go beyond the standard training approach long supported by the DOE and place more focus on overall building performance.

The paper's authors have significant commercial energy code experience covering the last 15 years. Four comprehensive statewide compliance studies and an impact evaluation of national ARRA-funded energy code efforts have been completed. An evaluation of compliance enhancement programs in New York is also now underway. These efforts include field evaluation of construction practices as well as "Delphi panel" discussions and extensive interviews with code officials and design practitioners. In addition, the authors have trained hundreds of code officials and design professionals across several states. From these efforts there is clear and mounting evidence that compliance is improving in localities where there are active high performance building programs. Whether the programs involved are "stretch codes," LEED™, NZE target programs, or high-performance buildings programs such as New Buildings Institute's Advanced Buildings program, there is evidence that these programmatic efforts assist in improving energy code compliance overall, not just for the participant buildings. These findings lead the authors to propose that efforts should further shift from "pushing" code compliance with standard training efforts to "pulling" code compliance through support of better-than-code code high performance building programs. This shift in focus will allow the leveraging of efficiency program efforts with code compliance efforts and will align instructional efforts with the interests of the design community.

Introduction

Building energy codes in the U.S. have come a long way in the past three decades, increasing in complexity along the way. This is especially true for the commercial building sector, where codes have rapidly transitioned from representing basic minimum building performance levels, to requiring performance features that are on a path toward supporting high performance buildings and eventually zero net energy (ZNE) buildings. For commercial construction, the advancements in the code are comprehensive, affecting design and construction across multiple sectors and requiring that nearly all parties involved in a building coordinate their efforts to achieve compliance.

The authors' extensive experience in codes includes conducting four statewide compliance studies, an impact evaluation of national ARRA-funded energy code efforts, and training hundreds of code officials and design professionals across several states. From these efforts, it is clear that the existing mechanisms to provide technical support and training for the code, inspire advanced building design, and evaluate the success of code programs, must evolve to match the increasing complexity of codes. This paper provides an overview of this evolution of energy codes and the emerging trends expected to drive energy codes of the future. Within this changing landscape, the paper assesses the role of high performance building programs in improving energy code compliance and the efficiency of buildings in general, and then provides recommendations regarding how program administrators (PAs) and states should innovate their approaches to advancing code knowledge, improving enforcement practices, and increasing the value of compliance assessments to identify additional energy savings opportunities.

Background on the Evolution of Commercial Energy Codes

An examination of the history of energy codes and emerging proposals for the future of codes helps establish a framework for assessing the current and proposed roles of PA support programs that effectively complement the code.

The first formalized energy codes grew up largely as a reaction to the 1973 oil embargo and increasing concerns regarding energy security from the resulting oil crisis. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) first published Standard 90, titled Energy Conservation in New Building Design, in 1975 (ASE 2013). For many architects and engineers, this standard was the first glimpse into the energy impacts of their building design decisions. The objective of the initial energy codes was to establish a minimum level of performance that all buildings should meet. Setting minimum efficiency thresholds for equipment and systems enabled more robust analysis of the energy consumption of buildings and changes in consumption over time.

Increasing Stringency and Complexity of Codes

ASHRAE Standard 90 (and its commercial specific derivative, Standard 90.1) has been issued many times since 1975, with new versions released every 3 years since 2001. A second code development body, the International Code Council (ICC), started publishing both commercial and residential energy codes versions, the International Energy Conservation Code (IECC), on a similar 3-year cycle since 1998.[1] Each new version of the energy code has increased the efficiency requirements, effectively encouraging the design and construction industry to incorporate new and more efficient equipment and design approaches into commercial buildings. The Pacific Northwest National Laboratory (PNNL), in collaboration with DOE, has

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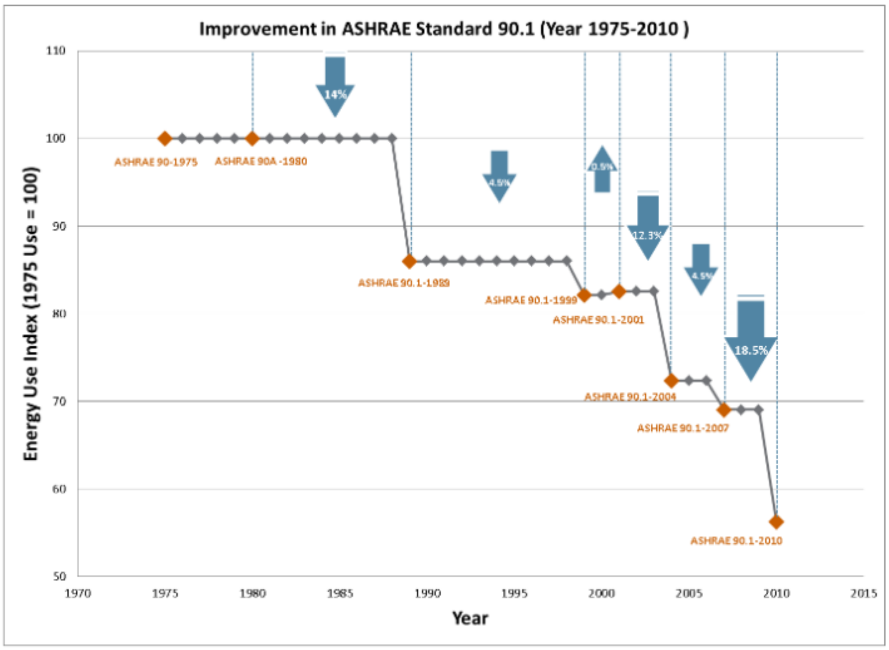
[1] The ICC is the successor organization to the Council of American Building Officials (CABO), which has been developing model codes since at least 1992.

developed estimates of the improvement in ASHRAE and ICC codes over time, suggesting that codes have improved significantly in terms of each version's equivalent energy use index (see Figure 1). Additionally, each new version of the code is becoming more complex, with increasing specificity in requirements and exemptions to each requirement. Also, more and more of the prescriptive requirements are becoming mandatory in codes; this is especially true for the mechanical equipment and lighting sections of the code.

Figure 1. ASHRAE Standard 90.1 Improvement Index



(Livingston et al. 2014)

Impact of Federal Legislation on Codes

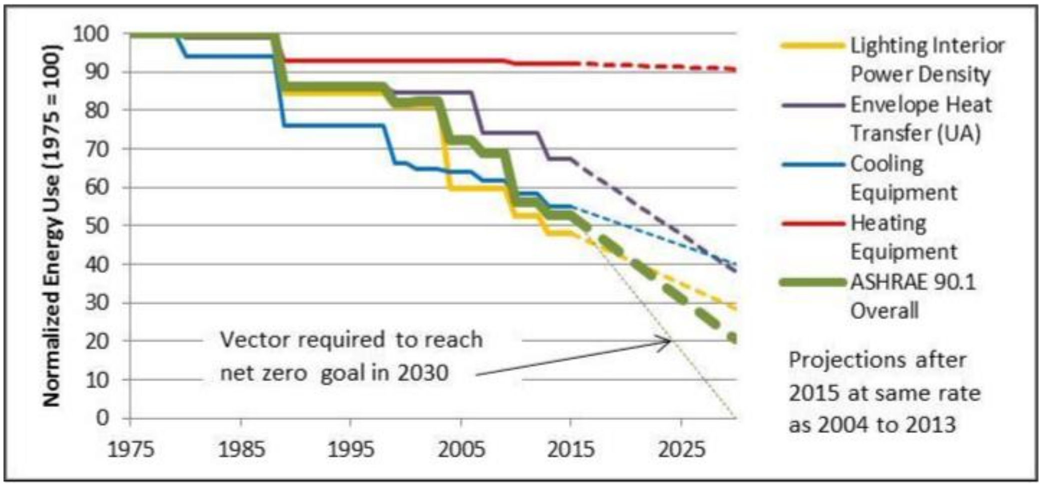
While the adoption of energy codes has historically been and continues to be a state-level decision, federal legislation has been effective in advancing energy code development, promoting code adoption, and supporting code compliance. The Energy Policy Act of 1992 required the U.S. DOE to be actively involved in the development of energy codes, working closely with state and local governments as well as the building code development community. Additionally, this act required the DOE to evaluate each version of ASHRAE 90.1 to determine the incremental energy savings for commercial buildings beyond the previous iteration of the standard (Halverson, Shui & Evans 2009). The DOE has taken an active role in energy codes in response to this mandate, both with ASHRAE 90.1 and with the IECC, providing code training, software, and other resources, and working closely with organizations like the PNNL to evaluate code savings and develop pathways for future codes.

The American Recovery and Reinvestment Act of 2009 (ARRA) mandated that states receiving federal funds for energy efficiency demonstrate at least 90% compliance with the energy code (IECC 2009 and ASHRAE 90.1-2007) by 2017. While no explicit enforcement mechanism has emerged to evaluate this requirement, the ARRA mandate has spurred multiple efforts to assess energy code compliance throughout the country.

The Future of Energy Codes: Shifting Towards ZNE

While energy codes in the short term are likely to continue the incremental increases in stringency in each subsequent version, in the long term the role of codes is shifting from setting the minimum requirements that all buildings must achieve to providing a road map for building design and construction to meet ZNE-ready buildings. Many stakeholders in the construction industry, such as ASHRAE and Architecture 2030, have stated explicit goals to achieve ZNE new construction by 2030. A recent PNNL study evaluating the progress of ASHRAE 90.1 and its various components suggests that if energy codes continue their increases in stringency at the pace of recent improvements, the codes themselves will fall short of producing ZNE buildings (Rosenberg et al. 2015).

Figure 2. ASHRAE 90.1 Improvements with Projections to 2030



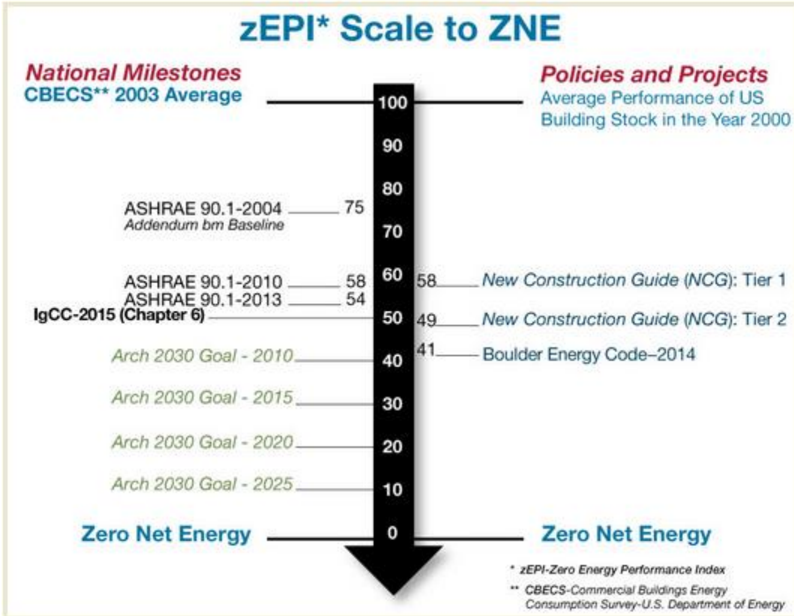
(Rosenberg et al. 2015)

The commitment to ZNE and the inadequacy of energy code projections to meet ZNE targets effectively changes the conversation from the evaluation of new versions of code as some percentage better or more efficient than the previous code, to instead setting a future performance goal for code (ZNE) and then evaluating, on an absolute scale, how much further each code version goes towards meeting that goal. Two complementary examples of this trend are the development of the Zero Energy Performance Index (zEPI) scale and outcome-based codes.

The zEPI Scale

The zEPI provides a scale for measuring commercial building energy performance based on energy use intensity (EUI) (NBI 2015). The zEPI scale very clearly sets the target of ZNE and is designed to shift the market approach to codes towards explicitly targeting zero on the scale. Each version of the energy code can be plotted on the zEPI scale and zEPI targets can be shared throughout the code development effort of future versions. Figure 2 shows the zEPI scale with the EUI pegged for recent ASHRAE and other energy codes.

Figure 2. zEPI Scale



(NBI 2015)

Outcome-Based Codes and the International Green Construction Code

Outcome-based energy codes are an emerging alternative compliance approach that enables buildings to demonstrate compliance from actual energy use rather than the traditional compliance methods of satisfying prescriptive requirements or modeled energy performance. Under an outcome-based codes framework, energy use targets are set by building type, size, and location, and the design team is given flexibility to develop a building that will meet these targets. Upon building completion, a temporary certificate of occupancy would be issued, and within 3 years the building owner is required to provide 12 continuous months of energy use demonstrating that the energy targets have been met. Outcome-based codes incorporate all the energy used in buildings rather than just the required code elements; this approach incorporates plug loads and other energy uses that are outside the scope of traditional code compliance, presenting greater insight into actual building energy use.

The benefits of outcome-based codes are magnified if they are incorporated in tandem with an absolute EUI scale such as zEPI. In conjunction with regular updates to the IECC, the International Code Council also develops the International Green Construction Code (IgCC), a code that goes beyond IECC to incorporate sustainability measures from design through construction and occupancy of buildings, as well as improved energy performance of 10%–15%. Organizations such as the New Buildings Institute (NBI) have been heavily involved in the development of proposed additions to the IgCC, and both zEPI and outcome-based codes will likely be included in the next iteration, the 2015 IgCC. Since many measures first outlined in the IgCC eventually get incorporated in future versions of the IECC, this is a promising step for these emerging trends and suggests that they will soon be incorporated more broadly into future codes.

High Performance Building Programs Improve Energy Code Compliance

While energy codes set the legal targets for building features and energy use, a number of high performance building programs exist in the marketplace to promote, incentivize, and/or require building practices that go above and beyond the base energy code requirements. Examples of high performance programs include state stretch (or reach) codes, LEED certifications, the NBI's Advanced Buildings programs, and the Collaborative for High Performance Schools (CHPS) protocols. These programs can be implemented at the federal or state level and can exist in conjunction with or as part of utility incentive programs. Though the structures of these programs vary somewhat, they are all designed to encourage the design and construction of energy efficient buildings that exceed the requirements of the energy code. Both IECC and the ASHRAE 90.1 standards allow an alternative path for code compliance where a project can adhere to an "above-code" performance protocol that is demonstrably stricter than the base code.

Recent compliance studies in Massachusetts, which have included interviews with code officials, architects, engineers, and building owners, as well as consistent feedback during code trainings, strongly suggest that the adoption of high performance building programs, by default, improves compliance for base codes (DNV-KEMA & ERS, 2012; DNVGL & ERS, 2015). Even when high performance building programs are not required by regulation or for program incentives, the interest they generate drives greater attention to energy-impacted building elements and improves compliance with base code requirements such as lighting controls, commissioning, air-sealing, etc. This factor creates opportunities for efficiency program administrators to influence code compliance while promoting above-code performance.

Case Study: Massachusetts Stretch Code

While high performance building programs are technically outside of the code, the adoption and promotion of these programs can have the added bonus of improving compliance with base codes. The Massachusetts Stretch Code, adopted in 2009 as part of the Massachusetts Green Communities Act, is an optional add-on to IECC 2009 that individual towns can adopt. Requirements and compliance methods vary slightly across building size and building type, but the general requirement is that new construction in stretch code communities exceeds IECC 2009 requirements by approximately 20%. As of October 2014, 146 towns and cities in Massachusetts had adopted the stretch code, representing approximately 53% of the state's population and the majority of commercial new construction activity, which is largely centered around Boston and other urban areas that have adopted the stretch code.

A recent code compliance study completed by the authors for both stretch and non-stretch communities in MA suggests that the stretch code's widespread adoption may be helping to improve compliance throughout the state. Designers and builders, seeking to comply with the stretch code's more stringent requirements, have an increased awareness of energy codes in general as well as the actual stretch code provisions. As these firms operate throughout the state, the benefits of their increased code knowledge cascade through all their projects rather than only those located within specific stretch code communities (DNVGL & ERS, 2015). This spillover is an additional benefit from high performance building programs such as the stretch code, and provides increased opportunities for energy savings throughout the state.

Code Support and Compliance Improvement Program Administrator Activities

Program Administrators (PAs) have consistently delivered energy code trainings and support programs designed to improve compliance with each subsequent version of the code adopted by their states. Despite the evolution of energy codes on a trajectory towards facilitating ZNE buildings, the majority of energy code support activities remain largely static, relying on conventional "push" approaches that regurgitate the code provisions in a classroom setting. To keep up with the code evolution, code support activities should adapt to "pull" buildings beyond the code by encouraging better-than-code programs.

While technically the energy code sets the statewide minimum legal requirement that all buildings must achieve, in practice it is widely recognized that few, if any, buildings meet all of the code's requirements. Regardless of methodology, code compliance studies routinely report compliance results that fail to exceed the 90% compliance threshold established in 2009 by ARRA. PAs have a longstanding interest in improving compliance with the energy code, both due to the legal standing of the code as well as the opportunity to claim savings from improving compliance to and even beyond code levels.

Traditional "Push" Approaches Encourage a Code Ceiling

The majority of energy code support activities are designed to disseminate the provisions of the energy code to the design, construction, and enforcement communities. These traditional approaches attempt to push buildings up to code-required performance levels. They are largely educational efforts with advocacy campaigns consisting of classroom training sessions that review each of the code provisions as though the goal for the training attendees was to memorize them for an exam. At the onset of energy codes, this was an effective approach when the energy code was new and not widely understood. Even as the stringency of the energy code increased, push programs have been effective at highlighting the changes to the code from one cycle to the next to increase the overall knowledge base of the code communities.

Traditional code training sessions generally encourage developers, builders, and code enforcement officials to strive to meet the code-required levels. This leaves little margin for error; as soon as one provision on a project fails to meet a code requirement, that building technically does not meet the legally required energy code. By striving just for the code, these programs are encouraging the minimum requirement. This essentially sets a code ceiling, leaving the community striving to simply meet the requirements (R-value, equipment efficiency level, etc.) without providing a road map for better-than-code construction.

Despite the best efforts of the trainers, the code provisions themselves are rather dry, and the section by section regurgitation over a series of half-day sessions can lose its effectiveness. Once the community is aware of the existence of the code, these sessions often become "check-the-box exercises" that satisfy continuing education requirements.

Code Support Should "Pull" Buildings Above and Beyond the Code

While some elements of traditional push programs are necessary to maintain a base level of code awareness, the increasing complexity and stringency of the energy code necessitates the consideration of new approaches that, rather than tout the line-by-line requirements of the code, encourage design and construction professionals to build above and beyond the code. These programs should be designed to pull buildings beyond the code by promoting advanced building technologies and high-performance building programs. By striving for these better-than-code programs, the construction industry will improve its compliance with the base code levels as a by-product.

The focus of pull programs should migrate away from reciting the explicit requirements of the code and more towards teaching the intent of the code and why these code requirements were designed the way they were. Focusing on the building science behind the code provides training attendees with an understanding of the effects of specific requirements on overall energy impacts. The minutiae of the provision language are unlikely to stick when read verbatim during training sessions, and are better referenced by the design and enforcement communities outside of the formal training sessions.

Hands-on activities are incredibly effective in increasing comprehension of code intent. For example, when conducting energy code training in Rhode Island, the authors commonly engage attendees in collectively assessing the physical building where the training is held to assess compliance with the energy code. Additional activities, such as blower door testing, site visits at active and/or recently completed construction sites, and demonstrations of design software and construction techniques, can be even more effective at improving building science knowledge throughout the energy code industries.

Design communities specifically present an opportunity for "pull" programs, as the authors' experience with code training suggests that these groups can be quick to disengage from training sessions when confronted with mundane recital of code provisions. Code support programs that dive into the underlying science behind the code and the opportunities that new technologies emerging on the market present to go above and beyond the code can inspire these communities to implement these strategies in their own work. Successful code support programs motivate attendees to incorporate what they learn into their daily work, and the science and technologies at the cutting edge of energy efficient construction are an exciting means to achieving this success.

"Pull" Program Benefits for Code Officials.

Enforcement of the energy code is traditionally left to local jurisdictions. Code officials are responsible for conducting inspections throughout new construction and renovation projects to assess all applicable codes (fire, plumbing, mechanical, energy, etc.) and it is widely acknowledged – and confirmed by every energy code and training conducted by the authors – that code enforcement offices are almost universally overburdened and understaffed.

Maintaining a working knowledge of each code is a challenge. While traditional code training may at first glance seem most appropriate to review the provisions, it is more important for the code enforcement officials to understand the intent behind buildings: the components of proper envelope construction, mechanical equipment selection and installation, and the advantages and disadvantages of various lighting approaches. This knowledge helps code officials grasp core building components and they can assess individual provisions within this context using any of the several available reference guides published by ASHRAE and ICC. With the emergence of outcome-based codes and absolute energy scales such as zEPI (discussed above), there may be opportunities for code officials to streamline their on-site energy code inspections, knowing that there are post-occupancy reviews on consumption to confirm energy code compliance. This would enable the code officials to focus more attention on the fire and human health safety component of codes while also evaluating energy codes based on actual consumption.

Energy Code Evaluations: Compliance Rate vs. Savings Opportunity

While legal energy code compliance remains under the jurisdiction of the code enforcement offices, the PAs are increasingly interested in evaluating statewide compliance with the energy code and tracking this compliance over time. To meet this need, the evaluation community has traditionally employed a variety of methods to evaluate compliance with the energy code. These compliance studies generally seek to estimate the percentage of buildings that satisfy the requirements of the energy code or the percentage of code requirements that are met by the average building, resulting in a rate of code compliance for the state. The American Recovery and Reinvestment Act of 2009 (ARRA) mandated that states receiving federal funds demonstrate at least 90% compliance with the energy code by 2017. However, while entities like the DOE and PNNL have proposed compliance methodologies for consideration, there is no mandated methodology that all compliance studies must follow. This has resulted in a wide variety of approaches and resulting compliance rates that are difficult to compare across states and over time.

While focusing on compliance rates and their increases over time can provide some insight into the success of code support programs, the most important component that is commonly missed by compliance assessments is the savings opportunity available from increased compliance. Energy code evaluations and assessments should go beyond simply reporting compliance rates by incorporating the savings opportunities available to PAs. Weighting provisions by energy impact, in a similar approach to the PNNL compliance checklist, can help identify specific prescriptive areas where improvements in compliance could have large relative impacts. For example, in a 2015 assessment of energy code compliance in Massachusetts, the authors assessed statewide compliance by weighting the provisions of the energy code by relative impact specific to the MA climate zone. This prescriptive assessment also identified specific provisions, such as daylighting, building commissioning, and duct sealing, where PAs should focus additional training and support to improve overall building construction.

Taking this one step further, evaluations can use compliance rates as an input in a model that considers the volume of anticipated construction in a state and corresponding EUI data to estimate the savings potential across a variety of building types from increases in code compliance. Iterations of this approach can be conducted to understand the role of increased compliance and changes in the energy code on projected building energy consumption.

Conclusions

The path forward for increasing energy savings from building energy codes is two-pronged: enhance the code provisions and better understand and quantify the "lost" savings opportunities related to noncompliance. The increasing complexity of codes and the shift towards encouraging ZNE and high performance buildings require that the support mechanisms and compliance assessment tools also evolve to successfully implement these changes. Traditional code training to push buildings up to code will fail to achieve this end. The prescriptive nature of compliance training and assessment is the limiting factor; when the focus is on each provision independently, savings are left on the table. Energy code programs should encourage advanced design and high performance buildings by focusing on the basic building science behind the code and enabling alternative paths to demonstrate compliance. Shifting the focus away from simply identifying compliance rates and towards assessing the actual energy use of buildings post-occupancy will help PAs realize greater savings.

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