Global Buildings Performance Network

Building Policies for a Better World

Technical Reports

A COMPARATIVE ANALYSIS OF BUILDING ENERGY EFFICIENCY POLICIES FOR NEW BUILDINGS

February 2013

COPYRIGHT

Published in February 2013 by Global Buildings Performance Network

ACKNOWLEDGEMENTS

Authors
Niamh McDonald (GBPN) / Jens Laustsen (GBPN)

Photo credits
Cover photo © GBPN

ACKNOWLEDGEMENTS

This report was developed by the GBPN with the input of various experts, based on the vision of facilitating the development of dynamic and ambitious building codes. Many international experts and code officials were involved in the process of developing a multi criteria comparison of building codes and policies for new buildings. This research builds on the earlier work of the authors while working at the International Energy Agency and on the development of regulation at a national and international level. A large number of people provided input into this project and we would like especially to thank the following:

The GBPN would like to express it's thanks to Karl Wakelin for his extensive involvement in the collection and analysis of data relating to the building codes included in this study and his contribution to the development of this multi-criteria "Policy Comparative Tool".

Sixty-four international building energy code experts participated in the development of the fifteen criteria and many were also involved in the development of sub questions and in the scoring process. We would like to thank all of these experts for taking the time to contribute their valuable comments and feedback. This input was very much appreciated and contributed significantly to robustness and impartiality of the project. The experts included: Alesia Ward, TWGI; Alesia Kahn; Alexandra Novikova, Climate Policy Initiative; Alpana Jain, Shakti Foundation; Arturo Echeverria, Mexican Industry; Bipin Shah, WinBuild, Inc; Bogdan Atanasiu, BPIE; Christiane Egger, O.Oe. Energiesparverband; Constant Aerschot, Lafarge/WBCSD; Craig Silvertooth, Center for Environmental Innovation in Roofing; Curt Garrigan, UNEP SBCI United Nations Environment Programme; Dan Staniaszek, BPIE; Diana Ürge-Vorsatz, Central European University; Eduardo Maldonado, Porto University/Concerted Action EPBD; Felicitas Kraus, DENA; Feng Liu, The World Bank; Florian Bauer, REEEP; Frank Klingenberg, Klingenberg Consultants; Frank Zegers, E4S Consult / MED ENEC Project; Greg Foliente, SCIRO; Horst Biedermann, CESARUS; Jayson Antonoff , IMT; Jeffrey Harris, Alliance to Save Energy; Jennifer Amman, ACEEE; Jennifer Layke, Johnson Control; Joe Huang, Whitebox Technologies; John Hogan; Katrin Klingenberg, Passive House Institute US; Ken Mentzer, Independent Consultant; Kevin Mo, CSEP; Kirsten Thomsen, SBI; Laura Van Wie McGrory, Alliance to Save Energy; Marina Economidou, BPIE; Mark Frankel, New Buildings Institute; Mark Hopkins, UN Foundation; Martin Hiller, REEEP; Maureene Guttman, Alliance to Save Energy; Meredydd Evans, PNNL; Niels Larson; Nils Borg, ECEEE; Oliver Rapf, BPIE; Per Heiselberg, Aalborg University; Peter Wouters, BBRI; Peter Bach, Danish Energy Authority; Peter du Pont, Nexant Asia Ltd.; Peter Hennike, Wuppertal Institute for Climate, Environment and Energy; Poul Kristensen, IEN Consultants Sdn. Bhd.; Randall Bowie, Rockwool; Rod Janssen, Consultant; Roger Hitchin, BRE; Ron Benioff, NREL; Ryan Meres, IMT; Satish Kumar, Schneider; Sean Penrith, Earth Advantage Institute; Siew-Eang Lee, National University of Singapore; Smita Candiwala, Shakti Foundation; Stefan Thomas, Wuppertahl Institute; Stephane Rue de la Can, LBNL; Steve Baden, RESNET; Susanne Dyrbøl, Rockwool; Thomas Boermans, Ecofys; William Sisson, UTRC; Wolfgang Eichhammer, Fraunhofer Institute; Yamina Saheb, IEA.

Thank you to those involved in the development of the codes at a regional, national or city level who provided us with valuable insights into each of the codes. This information was invaluable in helping us to develop an accurate picture of the code and supporting policies in each jurisdiction. Regional and national contributors included: Cengiz Kahramanoglu (Ontario), Duane Jonlin (Seattle), Gabrielle Schiffer (Oregon), Ian Finlayson (Massachusetts), Jim Magliano (Maryland), John H Lee (New York City), Hans-Olof Karlsson Hjorth (Sweden), Kirsten Engelund Thomsen (Denmark), Mazi Shirakh and Patrick Saxton (California), Michael Husted (Austin), Pekka Kalliomäki (Finland), Sarah Neary (Ireland), Scott Wilson (New South Wales), Stephen MOK (Singapore), Tomas Baranauskas (Lithuania).

LIST OF ACRONYMS

BPIE – Buildings Performance Institute Europe

BEEC – Building Energy Efficiency Code

CDD – Cool Degree Days

CSEP – China Sustainable Energy Programme

ECBC –Energy Conservation Building Code

EnEv - Energieeinsparverordnung

GBPN –Global Buildings Performance Network

GHG - GreenHouseGas

HDD – Heating Degree Days

IEA – International Energy Agency

IMT – Institute for Market Transformation

CONTENTS

EXECUTIVE SUMMARY

Energy use in buildings is responsible for more than 30% of global CO2 emissions and has a significant role to play in climate change mitigation, given the large potential savings in both new and existing buildings. A study completed by the Central European University commissioned by the Global Buildings Performance Network (GBPN) has demonstrated how far a transformative change of the building sector can bring us in terms of emissions reductions. In order to achieve this “deep” scenario, today’s best practice/state of the art buildings must become the standard in less than ten years from now. For new buildings this means that all buildings should develop towards net zero energy or very low energy standards.

For new buildings building mandatory energy efficiency codes are a central element in achieving these savings. Such codes need to be dynamic and ambitious and they need to be supported by a policy package with long-term targets of achieving zero or positive energy for all new construction. The GBPN aims to support the development of dynamic and ambitious building energy efficiency codes by identifying elements that are critical in the development of best practice building energy efficiency codes.

One of the main outcomes of the project has been the development of criteria for identifying best practice elements of dynamic and ambitious building codes and policy packages. These criteria were developed with the support of sixty-four global building code experts from the different regions and large international organisations. Twenty-five best practice building energy efficiency codes from the four GBPN regions and the rest of the world were scored based on these criteria. The results were used to form an interactive comparative tool that facilitates the analysis and comparison of best practice energy efficiency codes and supporting measures.

During the process of developing an interactive tool for assessing and comparing these twenty-five best practice building codes, a set of themes were identified as necessary for defining best practices in dynamic building codes that have the potential to move the building stock towards zero energy. These themes included a holistic approach, a dynamic approach, good enforcement, individual elements of performance and over all performance.

For each of the themes, three criteria were developed to assess different aspects of each theme. This resulted in fifteen criteria, which formed the central point of the assessment. Sub questions were developed for each criterion in order to assess how well the different criteria were addressed in the individual codes. Each sub question was then assessed and scored. Each criterion could be awarded a max of ten points.

Some of the sub questions address the same elements in different ways and it is not the aim that these criteria together form a total assessment of the best building code and complementing policy packages. In contrary it is the aim to show how each code can learn from best practices in other codes and to show that there can be different solutions to each of the elements in codes depending on the local conditions and the legal framework.

A committee of GBPN experts and an external consultant were involved in the scoring of the individual criteria in the assessment. Codes were scored by theme with one theme scored at a time across multiple codes. All points in each code were scored and reviewed in combination. Once all of the codes were scored a second round of committee meetings were initiated to ensure the consistency of scoring. Finally a workshop looked across all quality elements of the scoring by multiple code and criteria comparison. The network of GBPN and external experts were consulted in the scoring process. Information was collected from experts in each of the twenty-five jurisdictions at several parts of the process and when there was doubt further information and assessment were collected. This ensured the consistency in the scoring of each theme and the objectively validating the scores awarded.

A special tool was developed for the comparison of the multi criteria comparison of codes. This tool allows for comparison of individual or a random selection of criteria. The scores awarded to each code are illustrated on the GBPN website in the Policy

Comparative Tool and can be reviewed by all users. This allows for an open feed back on selection of codes and the scoring of all the individual criteria or the sub questions. Users of website are encouraged to "play" with the tool, selecting and deselecting criteria/elements that are of interest to them, comparing the twenty-five codes selected by GBPN based on those criteria. The aim of the tool is to learn from scoring in different disciplines rather than determining who scores best overall.

The comparative tool aims to promote examples of dynamic and ambitious building energy efficiency regimes for new buildings with a particular focus on building energy efficiency codes. Twenty-five energy efficiency codes from across the GBPN regions (China, Europe, India and US) and some examples on codes from jurisdictions outside of the GBPN regions were selected to support this aim. Each code was selected based on their demonstration of elements of best practice as these were set in the fifteen criteria. They were also selected in order to highlight regional differences in best practices relative to climate so that all jurisdictions globally could learn from these codes and policy packages.

Codes were selected following a literature review of current best practice energy efficiency codes from within the regions and information from other databases. The GBPN regional hubs, IMT (US), BPIE (Europe) and partners, Shakti (India), and CSEP (China) provided considerable support in the selection of codes by reviewing the codes selected following the literature review and suggesting additional examples of progressive and dynamic codes from their respective regions. All the selected codes are among the best in their region and in their level of development. To be selected among the twenty-five was hence already a large achievement in itself.

The wide geographical spread of the codes included necessitated that climatic conditions were taken into consideration. A simplified climate model was developed based on heating and cooling requirements. Given the complex nature of comparing codes in relation to climate, the climate methodology is still underdevelopment and will be discussed further in the Positive Energy Buildings Laboratory section of the GBPN website. The comparison of the overall energy performance of these energy efficiency codes will also be discussed there as only very few codes included such values.

All of the data included in this tool will be available as open linked data on the GBPN website and experts will be encouraged to continue to collaborate on this project on an on-going basis. This way the launch of the tool will not be the end but the start of a collaborative learning process.

INTRODUCTION

Energy use in buildings is responsible for more than 30 % of CO2 emission and has a significant role to play in climate change mitigation. This can be achieved through a number of strategies with energy efficiency playing a leading role in providing a low cost solution (Ürge-Vorsatz et al., 2012). A study completed by the Central European University commissioned by the Global Buildings Performance Network (GBPN) has demonstrated how far a transformative change of the building sector can bring us in terms of emissions reductions if building energy efficiency levels are significantly increased (Ürge-Vorsatz et al., 2012). In order to achieve this “deep” scenario, today’s best practice/state of the art buildings must become the standard in less than ten years from now. For new buildings this means that all buildings should develop towards net zero energy or very low energy standards.

Energy efficiency policies and supporting programmes play an essential role in ensuring improvements in efficiency (Geller et al., 2005). By setting minimum requirements for the energy-efficient design and construction/renovation of new and existing buildings, energy codes and policies can ensure reduced energy consumption for the life of the building (Cochrane & Dunn, 2010). Building Energy Efficiency Codes (BEEC) that consider the life cycle of a building and that aim to overcome the many barriers to implementation are key instruments for green house gas (GHG) mitigation in the buildings sector. Energy efficiency requirements in building codes or energy standards for new buildings are therefore the single most important measures for ensuring the energy efficiency of new buildings. This is in particular the case in times of high construction activity or in countries with high economic development (Laustsen, 2008).

Despite the existence of a vast number of policies worldwide, the results of these policies in terms of reduced energy consumption in buildings are still below target[1]. It has been suggested that in order to achieve greater results, energy efficiency policy-making must be more dynamic in terms of a continuous closed-loop process that involves and balances “policy design, implementation and evaluation” (Morvaj, Z., & Bukarica, V., 2010). A report by Lawrence Berkley National Laboratory commissioned by GBPN indicates that an upscale of current practices is not enough to bring us to the “deep” scenario and that there is a need to increase actions significantly. It is suggested that the key to altering current trends is to prescribe mandatory, dynamic and ambitious building codes and supporting policy packages that are incorporated into long-term strategies. It is clear from the report that such requirements are essential in ensuring the support of the market in implementing best practices in energy efficient buildings and in driving the research and development of new and cheaper solutions for energy efficiency.

The GBPN aims to support the development of dynamic and ambitious building energy efficiency codes by identifying elements that are critical in the development of best practice building energy efficiency codes using specially developed criteria. It is also the aim of the GBPN to analyse the overall framework of the code and the related policies in order to support jurisdictions to further develop such codes and so that the full potential of energy savings can be realised.

---

[1] The emissions gap estimated by the UNFCC in 2020 for a “likely” chance of being on track to stay below the 2°C target is 8 to 13 GtCO2e (depending on how emission reduction pledges are implemented). This assessment shows that if countries fully implement their pledges, emissions levels will be reduced to below business as usual levels in 2020 but will not reach the 2°C target agreed upon (UNEP, 2012).

METHODOLOGY

Overview

The GBPN has chosen to work towards the implementation of the "deep" scenario, whereby today's state of the art energy efficient buildings become the norm in less than ten years from now. For new buildings this means that all buildings should develop towards net zero energy. The GBPN works to develop regional or locally adapted roadmaps that set out clear guidelines in order to move the building stock, both new and existing buildings, towards zero energy. For new buildings a key to realising this scenario are mandatory, dynamic and ambitious building codes that are integrated in to a policy package with long-term targets of achieving zero or positive energy for all new construction. Such codes are essential in ensuring a transformative change of the construction market for new buildings.

Based on this strategy, in 2012 the GBPN developed a project that sought to identify key themes and elements that support the development of policy packages that drive the building stock towards zero fossil fuel use. The project also aimed to look at building energy efficiency codes, as well as the overall policy framework necessary to support such a development. It therefore seeks to analyse policies in order to support the development of codes that ensure that the full potential of energy savings can be realised.

One of the main outcomes of the project has been the development of criteria for identifying best practice elements of dynamic and ambitious building codes and policy packages. The criteria were developed with the support of sixty-four global building code experts from the different regions and large international organisations, and were refined through multiple iterations. Twenty-five best practice building energy efficiency codes were scored based on these criteria and used to form the basis of an interactive comparative tool that facilitates the analysis and comparison of best practice energy efficiency codes and supporting measures. The tool aims to analyse the content and structure of state of the art building codes in order to highlight best practice elements of codes so that these elements can be combined to further strengthen today's "state of the art" and encourage the adoption and implementation of "best practice" codes in the future.

The interactive tool can be accessed on the GBPN website and encourages user participation by comparing and analysing the different criteria. The results displayed in the tool are open source and are free to access by any interested party.

Key Themes, Criteria and Sub-Questions

In order to support the development of roadmaps for positive energy buildings the GBPN, with the support of international experts, began to identify key themes common to "best practice" of dynamic and ambitious building energy efficiency codes and supporting programmes. A consensus process was used to develop supporting criteria and sub-questions that could be used as a tool to determine whether a code contained best practice elements.

Five Key Themes

As the project sought to identify building codes and policy packages that help transform the whole building stock towards energy positive buildings, the main focus of the research was on dynamic, ambitious building energy efficiency policies that could support that end.

The developed criteria were divided into five key themes that form the basis of dynamic and ambitious building codes aimed at reducing the consumption of new buildings to zero or close to zero energy. When buildings are developed towards zero or plus energy a holistic or systematic approach to the design and construction process is of critical importance. While the initial steps towards zero energy can be taken by improving individual parts of buildings it will not be possible to design a zero energy building by addressing individual components in isolation. It must be based on the overall performance of the building and the perfect balance between the individual elements. The first element of the systematic approach would hence be to develop towards more holistic thinking and to set the standards at a higher level taking the total energy consumption of the building into consideration. The first of the five themes hence had to be "A Holistic Approach to Buildings".

It was also clear from the research that the shift to zero energy could not take place in one single step. Such an approach would lead to bottlenecks and excessive costs. It was therefore clear that if zero energy targets were to be met a dynamic approach needed to be adopted. A dynamic approach should be based on several phases of improvement of energy requirements. A policy roadmap should be based on realistic targets that facilitate the gradual development of strengthened codes until all new buildings are covered by the code and expected to reach zero energy. The second of the five themes is therefore based on the dynamic process and future zero energy targets.

Even the best building codes are worth very little if they are not implemented to a high standard and properly enforced. Although such regimes often are established outside the remit of the code, they are key to achieving the actual savings. Compliance regimes can comprise of a number of different elements including inspection regimes, penalties or information and demonstration. It is rare that such systems are included in the codes themselves and often the bodies responsible for enforcement of the code are different from those that develop the code. It is also clear that codes alone do not make the big impact and the additional legislation or policies are crucial to ensuring high compliance rates. In light of the importance of compliance, proper implementation and supporting policies form the basis the third theme.

Many codes come from a more prescriptive basis and develop to performance-based codes over time as the requirements become more sophisticated. It was found that three major elements form the basis of overall performance, including; the buildings itself, how technical systems work and how well renewable energy is included both in passive terms and in active systems. As part of the assessment of the existing codes it is necessary to look at how well these three elements are treated and how they fold together. The fourth theme is therefore focusing on the different elements of these buildings codes.

The final theme looks at the already achieved level of energy efficiency. A code is only likely to achieve a high level of overall performance if it has already developed significantly in the right direction. It is therefore important to look at that actual level of these codes. Have these jurisdictions already started to do the walking or is it still mainly talking. Although it was expected to be difficult there was no way around looking at the overall energy performance.

Fifteen Criteria

With the five key themes identified as forming the basis of a "best practice" energy efficiency code, the GBPN began to develop a more detailed set of criteria to facilitate the rigorous assessment of codes and the supporting policies to determine whether they are indeed examples of "best practice". The methodology used to develop the criteria included a detailed desktop study of current literature in the field of building energy efficiency policy as well as a peer review process. Sixty-four building energy efficiency policy experts from academia, the private sector, national experts from different regions and international organisations, including the International Energy Agency (IEA), United Nations Environment Program (UNEP) and World Business Council for Sustainable Development (WBCSD) participated in the review of the criteria as well as the key themes. This collaborative and open process ensured the transparency and robustness of the criteria developed.

As part of the desktop study, major research reports and academic papers on building energy efficiency policy from around the world were reviewed in order to gather information on current best practices and the assessment of best practice. In light of the outcomes of the desktop study, a tentative framework for the assessment of best practice energy efficiency codes was developed. A number of assessment criteria formed the basis of this framework.

An iterative process of feedback and refinement was followed whereby the criteria were re-issued to the experts following each round of review. Consensus or general support was eventually reached on fifteen criteria that now form the basis of the assessment of the individual key themes. The best practice criteria are defined in the table below:

Table 1. – Best Practice Themes & Related Criteria

Theme 1: **A Holistic Approach to Buildings:**	Theme: 2 **A Dynamic Process**	Theme 3: **Proper Implementation**	Theme 4: **Technical Requirements**	Theme 5: **Overall Performance**
1. Performance based approach	4. Zero Energy Target	7. Good Enforcement	10. Building shell	13. Overall performance/on-site
2. Performance to include all energy types or uses?	5. Revision Cycles	8. Certification	11. Technical Systems	14. Overall performance/primary energy
3. Energy efficiency and renewable energy	6. Levels beyond minimum	9. Policy Packages	12. Renewable Energy Systems	15. Overall performance/GHG emissions

As can be seen from the table above, each theme comprises of three criteria. Some of the criteria for the assessment of dynamic building codes for energy efficiency do not form part of the code itself but are part of a larger framework or a package of supporting initiatives. This framework is essential in ensuring the full impact of the codes. More detailed information on the criteria and how they support the assessment of each of the themes is outlined below.

The criteria under the first theme "Holistic Approach" are designed to assess the total performance of the building code with respect to end use, primary energy and GHG emissions. The criteria assess whether a performance-based approach has been adopted, if integrated bio-climatic designs are the basis of the code and also how much of the energy-use is included in the performance calculation. It also considers how renewable energy is taken into account in the overall performance.

An assessment of the dynamic nature of the code is carried out under theme two. The criteria under this theme seek to identify whether the code is frequently revised to include more ambitious energy efficiency targets such as zero energy targets and whether stakeholders are involved in this process from the start. There is also a focus on historic development, future aspirational levels and at long-term targets. For example, does the code include elements that encourage the construction of buildings beyond the minimum standard? This can include labelling or certification systems that incorporate well-defined classes that exceed the minimum standard for energy efficiency.

Following a review of the performance based approach and the dynamic nature of the code, theme three assesses the strength of the framework supporting the code. The criteria here focus specifically on assessing the stringency of implementation systems, the existence of mandatory certification and the use of policies to support codes and their future development. The criteria checks if systems ensure compliance through third party inspection or at a local authority level and assess how robust these systems are and how strongly they are enforced. These criteria also assess certification systems that support energy efficiency in the building codes.

The criteria under theme four assess all requirements for technical elements of the building code including individual building parts, technical systems and renewable energy. Demands for energy performance of the different parts can either be set prescriptively as a set of individual values or as part of performance value, which ensures a high level of performance for each of these elements. Codes with passive requirements, over all energy demands and over all performance can be an alternative way of fulfilling these prescriptive demands if they are set successively harder and ensure similar requirements for each part. These factors are considered under the criteria.

The criteria used under the fifth and final theme assess the total performance of the building code taking end use, primary energy and GHG emissions into consideration. The assessment can either be based directly on the demands within the code if these are set based on performance values and include all energy using systems or it can be calculated if the codes are mainly set based on prescriptive demands.

It is important to note that the criteria within each theme are cumulative and increasing in ambition, i.e. that building codes that do not meet the criteria in theme one or two are unlikely to meet those in theme four. Likewise, a code that meets all of the criteria in theme four is likely to have met all criteria within the previous themes. Only if themes one to four have been met to a certain degree will it be possible to have high demands for energy performance and to get a good score in the fifth theme.

Sub-questions

Once consensus was reached on the both key themes and criteria, the GBPN started to develop a set of sub criteria or questions that could be used for assessing each of these fifteen criteria. These questions were designed to investigate in further detail all aspects of each of the individual criterion. In light of the fact that it was not the intention to develop criteria leading to one conclusion, in some cases similar sub-questions are used under different criteria as they help to assess that criterion.

The sub-questions were also reviewed by many of the experts, although this group was smaller than the original group of sixty-four experts, and many proposals were collected during this process. For some elements this developed into a longer dialogue, which slowly improved this part of the research. Based on the development of a general consensus or strong support for the key elements of a dynamic energy efficiency building code, the GBPN used the elements as the starting point for the development of the comparative new building policy package tool that will be discussed in further detail in the following chapter.

Using the sub questions to rigorously assess the fifteen criteria also assisted the development of a scoring system for highlighting the differences between the codes assessed, in order to help the user to identify different best practices. For example, one code may have addressed "Technical Requirements" in a very comprehensive manner while another code may score well when it comes to a "Holistic Approach". Some of the sub-questions leave room for further improvements of codes while other criteria assess which codes had the highest performance and the rest is shown relative to this.

Below is an example of the criteria and sub-criteria developed for the first theme, "A Holistic Approach to Buildings". This example outlines the level of detailed consideration that was given to the assessment of each criterion:

Table 2. Criterion 1 – Performance Approach

Performance Approach
This criterion seeks to determine whether the code has adopted a holistic understanding of buildings in the sense that the main requests of the building code are based on total energy performance. This can either be based on a performance calculation or a figure based on metered consumption. The energy performance should include the balance and integration between different elements in the building and the technical system. Codes were assessed in order to determine whether the performance allows and stimulates integrated design or bioclimatic design principles adapted to the actual climate and whether it gives priority to passive design of buildings. The use of energy performance values should be mandatory. The following questions were used to support the assessment: 1. Does the code set an overall performance frame for buildings (kWh/m2 per year)?

2. Does the code take primary energy use, GHG emissions or peak loads into account?
3. Does the calculation take passive heating, passive cooling, natural ventilation, natural light and shading or other natural elements into account?
4. Does the code actively encourage integrated or bio-climatic design of buildings?
5. Does the code have a clear definition of building performance?

Table 3. Criterion 2. – Performance Including All Energy

Performance Including All Energy

This criterion assesses the energy uses included in the energy performance assessment of buildings as outlined by each code. The assessment includes energy used for heating and cooling, for lighting and for installed equipment and appliances. It also assesses on delivered or final as well as primary energy. Part of the assessment also focuses specifically on efficiency requirements for lighting, dehumidification, hot water, elevators, pumps, fans and transformers.

The following questions were used to support the assessment:

1. Do the requirements include most of the energy consumption in a building (i.e. heating, cooling, ventilation and dehumidification)?
2. Does the performance include domestic hot water?
3. Does the code include lighting requirements?
4. Does the code include energy consumption such as elevators, appliances, pumps and fans?
5. Does the code include conversion and transportation losses?

Table 4. Criterion 3. – Energy Efficiency and Renewable Energy

Energy Efficiency and Renewable Energy

This point assesses whether the building code encourages or mandates bio-climatic design and/or integrated design to optimize the use of passive energy. The focus is to firstly reduce energy use and then to ensure that energy requirements are met by indirect/passive energy. The majority of this passive energy should be supplied by local active renewable sources with the remainder supplied as efficiently as possible. The assessment also takes into consideration the use of overall lifecycle principles in design and implementation.

The following questions were used to support the assessment:

1. Does the code significantly reduce energy needs for instance by setting requirements for the buildings efficiency and renewable energy?
2. Does the code require/strongly encourage efficient use of passive heating and passive cooling?
3. Does the code require/strongly encourage natural ventilation?
4. Does the code require/encourage daylight use?
5. Does the code require/encourage shading?
6. Does the code require/encourage a reduction for energy provided for renewable energy systems?
7. Does the code include life cycle assessment?

DEVELOPING A TOOL FOR MULTI-CRITERIA COMPARISON

The GBPN recognised the need for a comparative, analytic tool to conduct a comparison of multiple elements of best practice in selected buildings codes. An initial desktop study confirmed this lack of tools for the comparative analysis of building energy efficiency policies – This was further confirmed by many of the experts involved in this project who also stressed the large challenge in comparing building codes between regions and climates. The themes, criteria and sub-questions described above form the basis of this tool.

The tool seeks to allow users to firstly identify best practice elements and secondly to compare the approach adopted by different codes in addressing these elements. It is the aim of the tool that it should be possible to compare one or more criteria for best practice and help the user to find where good and best practices can be learned in this particular field. The interesting thing is not to find one single best practice code or to rate codes from best to worst but to highlight elements of best practice to enable those involved in policy making to learn from other good examples in order to develop their existing policies towards zero energy. This tool has been developed on the assumption that there is a need for a whole package of measures to bring us to the deep path and it assesses how building codes can play a key role in such policies for new buildings. The GBPN believes that all codes can be improved particularly when it comes to their practical implementation as was highlighted by the tool and many of the involved experts.

If we are to ensure that today's state-of-the-art buildings become the norm by 2020, such tools represent an excellent opportunity to inform the development of dynamic and ambitious energy efficiency policies that will quickly move the building stock towards zero energy and beyond in a relatively short time frame.

Scoring Principles

In order to accurately compare best practice dynamic energy efficiency building codes it was necessary to develop a scoring system that reflected the true nature of existing policies. As outlined above, the sub-questions for each criterion were used as the basis for scoring the codes. Each criterion was assigned a max score of ten points with the ten points distributed amongst the sub-criteria depending on the importance of each question. A score of ten was awarded to examples of absolute best practice or perfect development in this field. Under some of the criteria none of the codes or policy packages assessed achieved the maximum score. In other criteria such as overall performance or best individual elements, the highest score was automatically given to the building code or policy package, which performed best. See example table below:

Table 5. Scoring Matrix (Further matrices of each criteria and related scoring can be found in the appendices)

THEME 1:	HOLISTIC APPROACH	SCORE
Criterion 1:	**Performance Based Approach**	
	Does the code set an overall performance frame for buildings (kWh/m2 per year)?	5
	Does the code take primary energy use, GHG emissions or peak loads into account?	2
	Does the calculation take passive heating, passive cooling, natural ventilation, natural light and shading or other natural elements into account?	1
	Does the code actively encourage integrated or bioclimatic design of buildings?	1
	Does the code have a clear definition of building performance?	1

Given the complexity of scoring building codes, a group of energy efficiency experts including members of the initial advisory group were asked to review the scoring system and to provide critical feedback in order to ensure that each sub-criterion was appropriately weighted. Once the scoring system was agreed upon, the data collected and inputted into the standardised spreadsheet was used to answer the questions asked under each criterion. The codes were then scored based on the existence of the relevant information for each criterion.

A Scoring Committee including multiple GBPN experts and an external consultant was established to work on the scoring of each of the codes. This committee approach removed any subjectivity from the scoring process ensuring the impartiality of the process. Codes were scored by theme with one theme scored at a time across all codes. This ensured the consistency of scoring on each theme. This process was repeated for all of the themes across all codes. Once all of the codes were scored a second round of committee meetings were initiated to ensure the consistency of scoring. Finally a workshop looked across all quality elements of the scoring by multiple code and criteria comparison. GBPN regional hubs also played an important role in the assessment and the scoring process, providing valuable insights into the adoption, implementation and operation of many codes, thus objectively validating the scores awarded. The GBPN regional hubs were involved in reviewing the final scores and when there was doubt, the local jurisdictions were contacted for further collection of information.

The scores awarded to each code are illustrated on the GBPN website in the Policy Comparative Tool and can be reviewed by all users. Users of website are encouraged to "play" with the tool, selecting and deselecting criteria/elements that are of interest to them, comparing the twenty-five codes selected by GBPN based on those criteria. Based on the score awarded to a code under each criterion, segments of an icon will increase and decrease (Please see Figure 1. below). The main aim of the tool is to learn from scoring in different disciplines rather than determining which code scores best overall.

The Policy Comparative Tool allows for feedback on both the scoring and the collected information. It is the aim that this transparent process can facilitate continuous learning and improvement of the tool and the data contained therein.

Figure 1. Image of GBPN Building Code Comparative Tool (2 Criteria Selected)

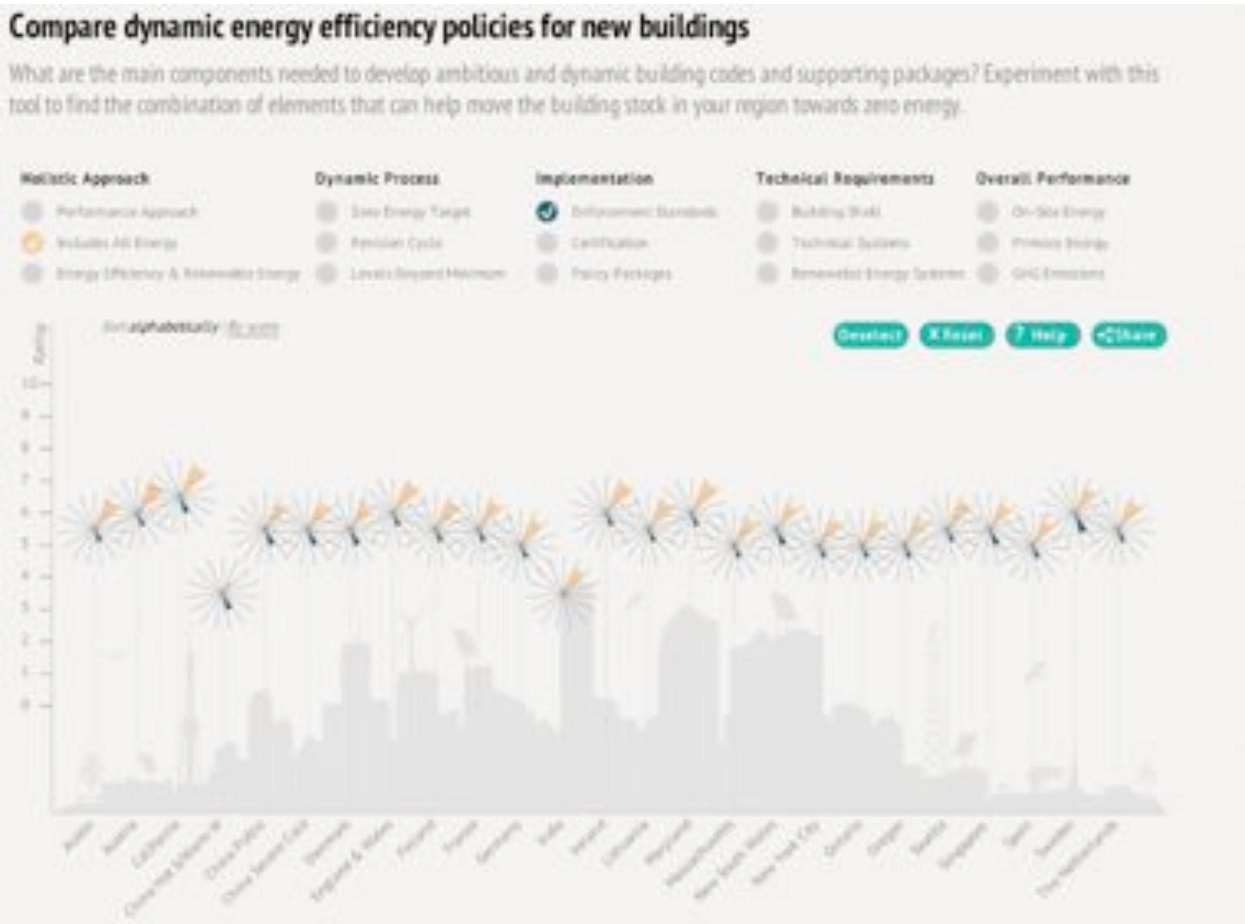
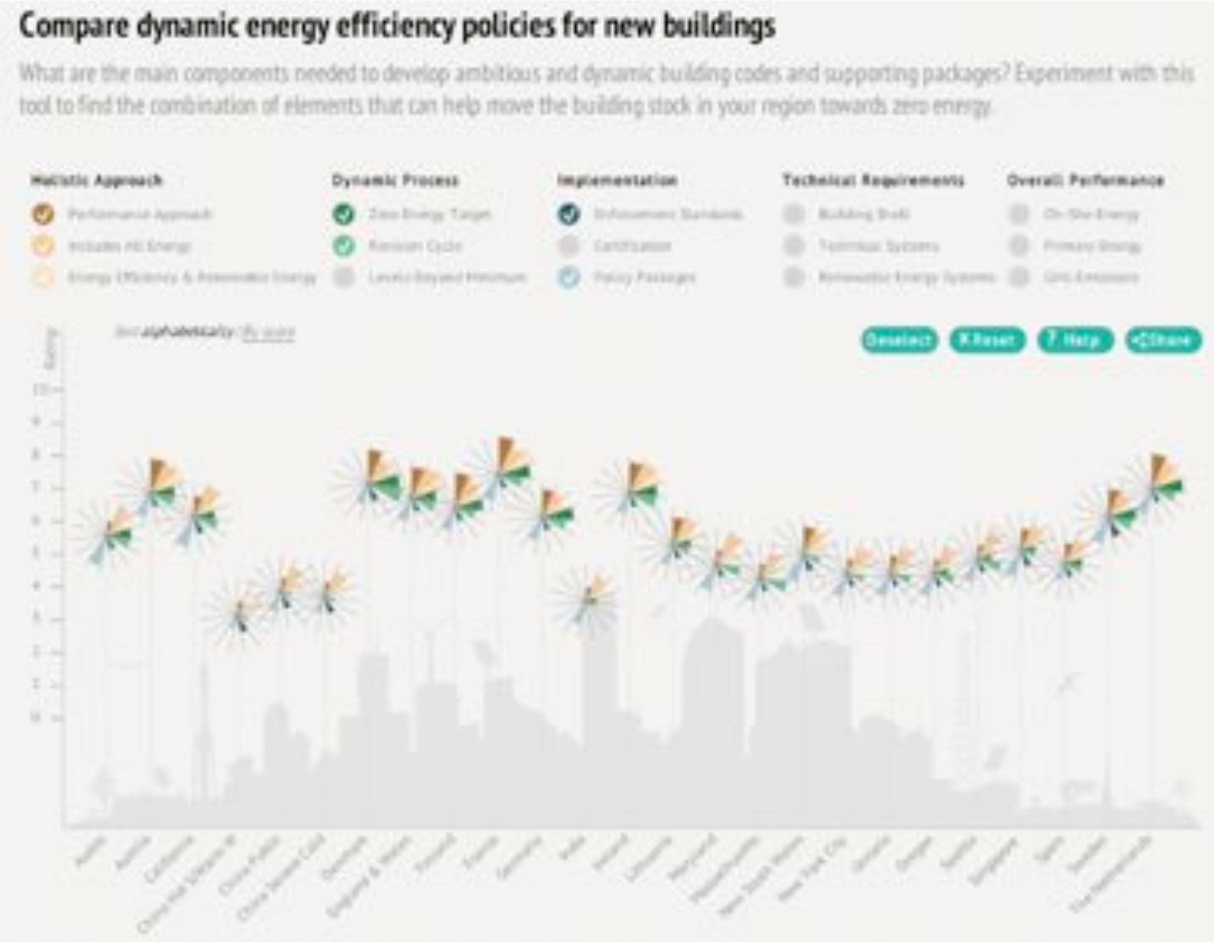


Figure 2. Image of GBPN Building Code Comparative Tool (7 Criteria Selected)



APPLICATION OF THE TOOL

Selection of Best Practice Building Energy Efficiency Codes

One of the aims of developing the comparative tool was to promote examples of dynamic and ambitious building energy efficiency regimes with a particular focus on building energy efficiency codes. In light of this aim, twenty-five energy efficiency codes from across the GBPN regions (China, Europe, India and US) and some examples of codes from jurisdictions outside of the GBPN regions were selected. Each code was selected according to their demonstration of elements of best practice. They were also selected in order to highlight regional differences in best practices relative to climate etc. All the selected codes are among the best in their region and in their level of development. To be selected among the twenty five was hence a large achievement in itself.

Codes were selected following a literature review of current best practice energy efficiency codes from within the regions and information from other databases. The GBPN regional hubs, IMT (US), BPIE (Europe) and partners, Shakti (India), and CSEP (China) provided considerable support in the selection of codes by reviewing the codes selected following the literature review and suggesting additional examples of progressive and dynamic codes from their respective regions. The codes from outside the GBPN regions were selected on the basis of the literature review and also through collaboration with international experts.

The original thirty codes selected were then narrowed to twenty-five as it was decided that similar findings would result from a number of these codes. It is anticipated that additional codes will be reviewed in future and it is also intended that the scoring of existing codes will be reviewed in light of any improvements or updates to the code. The codes selected are listed below and have been grouped according to the region:

Table 6. – Selected Best Practice Energy Efficiency Codes

Europe	**United States**	**India**	**China**	**Rest of the World**
Austria	California	India (Energy Conservation Building Code)	China – (Hot Summer/ Warm Winter Zones)	New South Wales
Denmark	City of Austin		China – Public Buildings, All Zones	Ontario
England & Wales	Maryland		China - Severe Cold and Cold Zones	Singapore
Finland	Massachusetts			
France	NYC			
Germany	Oregon			
Ireland	Seattle			
Lithuania				
Netherlands				

Spain				
Sweden				

Given the global nature of this study, it was clear from the literature review that a number of local or regional factors can affect the status of the code and that codes and supporting measures need to be adapted and developed with respect to the local context. These factors include financial and technical development, political structures and cultural norms. Despite these local factors, some dynamic core elements of a best practice energy efficiency codes remain useful and replicable across regions. Regions and jurisdictions with less experience in the development of codes in particular can learn from jurisdictions with a long history of developing codes and supporting measures, but all codes can be improved.

Climate Comparison

The wide geographical spread of the codes included in this comparative analysis necessitated that climatic conditions were taken into consideration. A simplified climate model was developed by the GBPN based on heating and cooling requirements. Given the complex nature of comparing codes in relation to climate, the climate methodology is still underdevelopment and will be discussed further in the Laboratory section on the GBPN website - Positive Energy Buildings. Further information on the model currently used to compare codes can be found in the appendix of this report as well as on the website.

DATA COLLECTION

Following the development of the assessment criteria and the identification of twenty-five best practice codes, the research identified relevant information necessary for assessing and comparing current practices in the countries and regions of interest against the criteria. The information reviewed included official building code documentation from each jurisdiction, supporting regional, national and international legislation, policy packages and relevant documents. Information was collected about each of the codes and entered into a standardised spreadsheet so that the same basis for comparison existed for each of the codes. Information included in the spreadsheet included general background information, coverage of the code, the type of code, performance values, enforcement etc.

Where information gaps in literature existed, a questionnaire containing approximately twenty-five technical questions was compiled and sent to country experts and programme implementers to obtain up-to-date and detailed information necessary for the assessment. The response rate to the country specific questionnaires was good with responses from twenty-one of the twenty-five code experts. In some cases interviews were set up with local code experts to discuss elements in further details.

All of the data included in this tool will be available as open linked data on the GBPN website and experts will be encouraged to continue to collaborate on this project on an on-going basis. This way the launch of the tool will not be the end but the start to a collaborative and learning process with the aim of constantly sharing and comparing details of the most advanced building energy efficiency regimes.

CONCLUSION

The interactive "Policy Comparative Tool" is an innovative tool that clearly outlines the mechanisms behind dynamic building codes and policies. The tool facilitates the comparison and analyses of best practice energy efficiency codes to enable those involved in policy making to move the building stock towards zero energy based on an individual selection of criteria.

The codes reviewed outlined many best practices, but one of the main findings of this research has been that there is no one perfect code and there is still much work to be done in order to move the building stock towards zero energy in less than ten years from now. It is important to note that progress can be made in all areas, particularly with regard to enforcement of the codes. The need for more onsite construction inspections, post-occupancy energy verification, inspector training and compliance statistics was highlighted. In many cases renewable energy requirements and zero energy targets are either lacking stringency or are non existent, something that needs to be addressed if new codes and policies are to significantly reduce building related CO_2 emissions. The "Policy Comparative Tool" can be used to facilitate this progress by assisting those involved in policy development to find best practice solutions from across the regions. The tool demonstrates that there can be multiple solutions to a problem, allowing people to search for solutions that are best suited to their individual jurisdiction.

This paper is part of a series of papers on the "Policy Comparative Tool". Other papers in this series will focus on results of the tool and on the climate methodology developed. Both papers will soon be available on the GBPN website.

REFERENCES

Agence Française de Dévelopment (2008). Promoting Energy Efficiency Investments – Case Studies in the Residential Sector, IEA.

Bloom & Wheelock (2012). Executive Summary - Zero Energy Buildings, Global Market, Regulatory, and Technology Analysis for Energy Efficiency and Renewable Energy in Commercial and Residential Buildings, Pike Research.

Chandel & Aggarwel (2008). Implementation of Passive Solar Housing Technology in Western Himalayan State of Himachal Pradesh. Solar Energy Research Group.

Cochrane, Dunn (2010). Energy Codes 101: A Primer for Sustainability Policy Makers, Working Paper, and Reservation Green Lab.

Cohan, Hewitt & Frankel (2010). The Future of Energy Codes. ACEEE Summer Study on Energy Efficiency in Buildings. Available at: http://www.aceee.org/files/proceedings/2010/data/papers/2170.pdf [Accessed: December 2012]

DeGuire (2011). Net Zero Energy: Technologies and Approaches to Transform the Built Environment- An Overview, Institute for Building Efficiency.

Diana Urge-Vorsatz (2012). "Best Practice Policies for Low Energy and Carbon Buildings. A Scenario Analysis". Research report prepared by the Center for Climate Change and Sustainable Policy (3CSEP) for the Global Buildings Performance Network. .

DOE (2011). Going Beyond Code - A Guide to Creating Effective Green Building Programs for Energy Efficient & Sustainable Communities.

Dunn, Denniston, Antonoff, DiNola (2010). Toward a Future Model Energy Code for Existing and Historic Buildings. WORKING PAPER, Preservation Green Lab National Trust for Historic Preservation, New Buildings Institute, City of Seattle, Green Building Services Inc. Available at: http://www.energycodes.gov/states

Ecofys (2011). U-values for Better Energy Performance of Buildings - "Mitigation of CO2 Emissions from the Building Stock – Beyond the EU Directive on the Energy Performance of Buildings.

Energy Sector Management Assistance Program (ESMAP) (2011). Good Practices in City Energy Efficiency, Tianjin, China – Enforcement of Residential Building Energy Efficiency Codes. Energy Sector Management Assistance Program, Energy Efficient Cities Initiative.

European Commission (2009). Low Energy Buildings in Europe: Current State Of Play, Definitions and Best Practice. Brussels: EC, September 2009.

Evans, Shiu & Delgado (2009). Shaping the Energy Efficiency in New Buildings - A Comparison of Building Energy Codes in the Asia-Pacific Region. Pacific Northwest National Laboratory.

Evans, Shiu & Somasundaram, (2009) Country Report on Building Energy Codes in India. Pacific Northwest National Laboratory. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17925.pdf.

Field & Soper (2010). Comparing building performance assessment in the UK the USA and Sweden - lessons and opportunities for harmonization,

Gann, Wang & Hawkins (1998). Do regulations encourage innovation? - The case of energy efficiency in housing. *Building Research & Information, 26:5, 280-296.* Available at:http://books.google.fr/books?hl=en&lr=&id=nt_iC7EBP94C&oi=fnd&pg=PP1&ots=BqdqYcfNBw&sig=rrUpmbMGxrWZV_mNZcWr1Llp-nw#v=onepage&q&f=false

Geller, H., Attali, S., & Consultants, I. C. E. (2005). The experience with energy efficiency policies and programmes in IEA countries. Learning from the Critics. Paris: IEA. IEA Information Paper.

Greentech Knowledge Solutions (2011). Market Assessment of Solar Water Heating Systems in Five Potential States/NCR Region.

Guttman (2012). EESI Briefing - Energy Codes, Building Codes Assistance Project.

Halverson, Shui & Evans (2009). Country Report on Building Energy Codes in the United States. Pacific Northwest National Laboratory.

Huan, Lang, Hogan & Jin (2003). An Energy Standard for Residential Buildings in South China. Lawrence Berkeley National Laboratory, Berkley, California.

Huang and Deringer, (2007). Strategy Roadmap for Net Zero Energy Buildings in India. US AID India, BEE.

IEA (2008). Promoting Energy Efficiency Investments – Case Studies in the Residential Sector. IEA, Agence Française de Dévelopment, 2008. Avalable at.: http://www.iea.org/publications/freepublications/publication/PromotingEE2008.pdf

IEA (2010). Energy Technology Perspectives - Scenarios and Strategies to 2050.

IEE (2010). Implementing the Energy Performance of Buildings Directive (EPBD) – Featuring Country Reports.

Jaiswai (2011). Accelerating Energy Efficient Building Design in India. ECOnirman, Switchboard, Natural Resources Defense Council Staff Blog. Available at: ,http://switchboard.nrdc.org/blogs/ajaiswal/accelerating_energy_efficien t.html

Kapoor, Deshmukh & Lal (2011). Status of Energy Efficient Building Codes in Asia (China, Hong Kong, Taiwan, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, India).

Kumar, Kapoor, Rawal, Seth & Walia (2010). Developing an Energy Conservation Building Code Implementation Strategy in India. International Resources Group, CEPT University, BEE and USAID India Mission.

Kumar, Sarraf, Seth, Pandita, Walia, Kamath & Deshmukh (2010). Performance Based Rating and Energy Performance Benchmarking for Commercial Buildings in India. International Resources Group, PS Collective, BEE, United States Agency for International Development.

Laustsen, J. (2008). Energy efficiency requirements in building codes, energy efficiency policies for new buildings. IEA Information paper. In support of the G8 Plan of Action. Paris: OECD/IEA, March 2008.

Li, Shepard, Layke & Currie (2012). Essential Buildings - The Emergence of “low-Carbon Cities” in Post-industrial urban China. Institute for Building Efficiency.

Maithel, Modi, Ameen, Bhanware & Rai (2011). Market Assessment of Solar Water Heating Systems in Five Potential States/NCR Region. Greentech Knowledge Solutions, New Delhi, 2011.

Meyers (2012). Energy Code Enforcement - Best Practices from the Southwest, Southwest Energy Efficiency Project (SWEEP).

Morvaj, Z., & Bukarica, V. (2010). Energy efficiency policy. *Book chapter, Book edited by: Jenny Palm, ISBN*, 978-953.

Pike Research, Bloom & Wheelock (2012). Executive Summary - Zero Energy Buildings, Global Market, Regulatory, and Technology Analysis for Energy Efficiency and Renewable Energy in Commercial and Residential Buildings.

R. Bartlett, M.A. Halverson & D.L. Shankle (2003). Understanding Building Energy Codes and Standards, PNNL, http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14235.pdf

Ries, Jenkins & Wise, (2009). Improving the Energy Performance of Buildings - Learning from the European Union and Australia. RAND, Environment, Energy, and Economic Development.

Taylor (2011). Technology Roadmap, Energy-efficient Buildings: Heating and Cooling Equipment. IEA.

UNEP (2007). Assessment of Policy instruments for Reducing Greenhouse Gas emissions from Buildings.

UNEP (2012). The Emissions Gap Report 2012 – A UNEP Synthesis Report. Paris.

UNEP SBCI (2009). Buildings and Climate Change – Summary for Decision-Makers. Available at: http://www.unep.org/sbci/pdfs/SBCI-BCCSummary.pdf [Accessed: December 2012]

Zhou, McNeil and Levine (2011). Assessment of Building Energy Saving Policies and Programs in China During the 11th Five Year Plan, Energy Analysis Department Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory.

APPENDIX ONE – FIFTEEN CRITERIA

Theme 1. Holistic Approach

This theme has three criteria that assess the holistic nature of building codes including their total performance with regard to end use, primary energy and GHG emissions. The assessments consider whether a performance-based approach has been adopted, taking into consideration how much energy is included and whether integrated or bio-climatic design forms the basis for the energy efficiency code.

Performance Approach

This criterion seeks to determine whether the code has adopted a holistic understanding of buildings in the sense that the main requests of the building code are based on total energy performance. This can either be based on a performance calculation or a figure based on metered consumption. The energy performance should include the balance and integration between different elements in the building and the technical system. Codes were assessed in order to determine whether the performance allows and stimulates integrated design or bioclimatic design principles adapted to the actual climate and whether it gives priority to passive design of buildings. The use of energy performance values should be mandatory.
The following questions were used to support the assessment:

- Does the code set an overall performance frame for buildings (kWh/m2 per year)?
- Does the code take primary energy use, GHG emissions or peak loads into account?
- Does the calculation take passive heating, passive cooling, natural ventilation, natural light and shading or other natural elements into account?
- Does the code actively encourage integrated or bio-climatic design of buildings?
- Does the code have a clear definition of building performance?

Performance Including All Energy

This criterion assesses the energy uses included in the energy performance assessment of buildings as outlined by each code. The assessment includes energy used for heating and cooling, for lighting and for installed equipment and appliances. It also assesses on delivered or final as well as primary energy. Part of the assessment also focuses specifically on efficiency requirements for lighting, dehumidification, hot water, elevators, pumps, fans and transformers.

The following questions were used to support the assessment:

- Do the requirements include most of the energy consumption in a building (i.e. heating, cooling, ventilation and dehumidification)?
- Does the performance include domestic hot water?
- Does the code include lighting requirements?
- Does the code include energy consumption such as elevators, appliances, pumps and fans?
- Does the code include conversion and transportation losses?

Energy Efficiency and Renewable Energy

This point assess whether the building code encourages or mandates bio-climatic design and/or integrated design to optimize the use of passive energy. The focus is to firstly reduce energy use and then to ensure that energy requirements are met by indirect/passive energy. The majority of this passive energy should be supplied by local active renewable sources with the remainder supplied as efficiently as possible. The assessment also takes into consideration the use of overall lifecycle principles in design and implementation.

The following questions were used to support the assessment:

- Does the code significantly reduce energy needs for instance by setting requirements for the buildings efficiency and renewable energy?
- Does the code require/strongly encourage efficient use of passive heating and passive cooling?

- Does the code require/strongly encourage natural ventilation?
- Does the code require/encourage daylight use?
- Does the code require/encourage shading?
- Does the code require/encourage a reduction for energy provided for renewable energy systems?
- Does the code include life cycle assessment?

Theme 2. Dynamic Process
This theme has 3 criteria that assess the dynamic elements of the code in terms of regular updates cycles. It assesses past revisions of the code as well as future targets and zero energy goals. The scoring further assesses how codes encourage the implementation of levels beyond code, driving innovation and increasing efficiency of building beyond the bare minimum.

Zero Energy Target
This criterion assesses whether a realistic target for having zero energy buildings as standard by a certain date has been set and whether an appropriate roadmap for achieving this has been outlined. The assessment also considers how much of the consumption is included in this definition. A target of this type is often set outside the code itself and should be adopted and strongly mandated. This assessment will have regard to such supporting regulations or agreements.

The following questions were used to support the assessment:
- Has the path to ZEB performance/compliance been clearly set out for the future?
- Are there binding targets based on a roadmap that are achievable, realistic and relevant to the country/region and state of the market? Are there aspirational targets for revisions towards zero energy?
- How quickly will a target for reaching net zero energy buildings be achieved (for instance by 2020 or 2030 been set)? Is this realistic given the actual state?
- Are all end uses included in this target?

Revision Cycles
This criterion seeks to assess whether there is a clear and well-documented process for ensuring regular updates of the energy requirements in building code. The clearer this process is mandated the better. It is also an advantage if goals or targets have been clearly defined as part of the process, such as aspirational targets. The code are further assessed based on how the process involves and informs important stakeholders at an early stage, with this being critical to the use and acceptance of codes.

The following questions were used to support the assessment:
- Does the code have regular and frequent revision cycles (max 3-5 years)? Has this process been followed in the past?
- Are key stakeholders involved in the development of new requirements? Is the development of the code followed by training activities?
- Does the code adoption take life cycle assessment into account? Are the requirements supporting a dynamic and ambitious development of codes by including economic rational and other benefits?
- Does the code or legislation have aspirational targets for the future revisions that have already been defined? Are targets clearly set out and well defined at least 2-3 years in advance?

Levels Beyond Minimum
Building codes set requirement for performance/maximum energy use. Codes or other policies should however strongly encourage design to go beyond these minimum requirements in building codes to prepare for future code revisions and their increased requirements. This criterion assesses whether the building code has included elements that encourage the construction of buildings beyond the minimum standard. This can include labelling or certification systems that include well-defined classes that exceed the minimum standard for energy efficiency. Classes that exceed current minimum standards should be supported by incentives and policies such as certification of buildings. Successful systems should document the possibility to go beyond the minimum standard.

The following questions were used to support the assessment:

- Does the code and complementing policies encourage buildings to go beyond minimum requirements?
- Is this well documented for instance by certification schemes introducing well defined classes "above standard level"?
- Can the code 'stretch' or 'reach' beyond minimum requirements and reward buildings that achieve significant savings on standard design? Does the code have low energy classes i.e. the code -20%, - 30% or - 50%?
- Are there any special requirements for public buildings to pave the way for the rest of the market and to demonstrate best practices and BAT measures?

Theme 3. Implementation

This theme has three criteria to assess the actual implementation of codes. The theme assesses the actual enforcement system, the use of mandatory certification and the use of policies to support codes and their future development.

Good Enforcement

This criterion assesses the robustness of structures in place to ensuring enforcement of the code and the compliance of individual buildings with the code. The assessment checks if systems ensure compliance through third party inspection or at a local authority level and how robust these systems are. It also considers how strongly this is enforced and whether there are penalties involved in the system. Furthermore, the criterion assesses whether compliance is checked during the design phase, after construction or both. A good enforcement system should include robust documentation and regular evaluation of the system itself.

The following questions were used to support the assessment:

- Is the code clearly mandatory rather than voluntary or semi-voluntary?
- Is there a clearly defined and robust control and verification system for assessing compliance? Does this necessitate on-site inspections during and after the construction process and is post-occupancy control included?
- Does the code require post occupancy energy verification?
- Are strong penalties for lack of compliance frequently enforced?
- Are surveys independently conducted on compliance rates and do they demonstrate a high rate of compliance?
- Are there adequate provisions for training of inspectors and is their work quality controlled?

Certification

Certification systems can be used to ensure code compliance, to support levels that go beyond the minimum and to inform on the actual levels of energy efficiency. This criterion assesses certification systems that support energy efficiency in the building codes. Certification can be used to provide information on performance and disclosure levels.

The following questions were used to support the assessment:

- Is building energy efficiency certification mandatory in all new buildings?
- Is it a positive label for a defined energy efficiency level that goes beyond the minimum?
- Will the result of assessment influence final compliance approval?
- Is the certification system robust and well integrated in the process?

Policy Packages

Energy requirements for new buildings are most effective if they work together with other policies. Building codes that are well integrated within a comprehensive strategy are able to lead to larger savings and help to drive innovation. Other policy instruments can include finance, information, training, demonstration projects or public procurement policies. These can help to shift the market and to develop new and more effective solutions. This criterion seeks to determine the existence of supporting policy packages and the quality of these packages.

The following questions were used to support the assessment:

- Is there a system of rating or labelling for major building components?
- Are there any special incentives or requirements for public buildings to pave the way for the rest of the market?
- Does the code link to and support stricter standards such as green buildings, passive houses, integrated design or bio-climatic design.
- Are there supporting measures, which increase energy efficiency and or allow minimum requirement levels to be exceeded (e.g. reduced property tax, higher incentive, better loan conditions, grants etc.)?
- Are there education systems to ensure capacity in all parts of the construction sector?

Theme 4. Technical Requirements

This theme includes three criteria for the assessment of individual building parts, the technical systems as well as the demands for use of renewable energy. Demands for energy performance of the different parts can either be set prescriptively as a set of individual values or as part of performance value, which ensures a high level for each of these elements. Codes with passive requirements, overall energy demands and overall performance can be an alternative way to fulfil these prescriptive demands as they are set successively harder and ensure similar requirements for each part.

Building Shell

This criterion assesses the requirements for building parts and the impact of these requirements on the building shell. Energy performance of specific building parts assessed will include low u-values for most important parts of the building and the thermal bridging requirements. Window requirements are assessed in order to determine whether they address over heating (G values), daylight supply and shading. Values can be set either prescriptively or in a more holistic way. Results are climate corrected by a simple set of factors.

- The following questions were used to support the assessment:
- Does the building code stipulate low maximum u-values for the most important building parts (at least walls, floors, roofs windows/skylights and doors)?
- Does the code stipulate low maximum psi-values or is thermal bridging included in the building envelope calculation?
- Are the u-values established relevant to the climate?
- Does the code require a strict level of air-tightness including testing?

Technical Systems

This criterion assesses the energy requirements for HVAC systems, lighting and other technical elements of the building. The individual parts of the HVAC systems are assessed individually and also as part of the overall system efficiency. This includes the use of automatic control systems and airtightness requirements. Assessment also takes into account regulations that favour passive energy systems where they can fully substitute active systems.

The following questions were used to support the assessment:

- Does the code require efficient and well-designed HVAC systems?
- Does the code require overall efficiency testing of technical systems? Does this include pressure testing of ducting systems when needed?
- Does the code include airtightness requirements?
- Does the code require heat recovery systems to be implemented when possible?
- Is commissioning a requirement of the code?
- Doe the requirements address efficiency of lighting installations?
- Does the code require minimum efficiency levels for domestic hot water?

Renewable Energy Systems

This criterion considers separate requirements for active renewable energy systems. Requests for active systems should be combined with encouragement of passive elements for heating, cooling, ventilation and day lighting. The assessment focuses on specific requests to supply the resting energy demands based on renewable energy systems. This can include solar systems for hot water, demands for PV systems, geothermal or the use of heat pumps. Requirements can be based on a holistic basis as part of overall performance if this ensures that the full or at least the remaining energy use is made by renewable energy sources.

The following questions were used to support the assessment:

- Does the code have separate requirements for use of active renewable energy? Does the total performance include active renewables?
- Does the code include all types of buildings?
- Are the demands stringent (highest demand will get three points)?

Theme 5. Overall Performance

This theme seeks to assess the total performance of the building code taking end use, primary energy and GHG emissions into consideration. The assessment can either be based directly on the demands in the code if these are set based on performance values and including all parts of the energy use or it can be calculated if the codes are mainly set based on prescriptive demands or a reference building calculation.

On-Site Energy

This criterion includes a general assessment of the maximal end use of energy in the building energy efficiency code. The assessment can either be based directly on the demands in the code if these are set based on performance values and including most parts of the energy use or it can be based on a calculated value if the codes are mainly set based on prescriptive demands or only cover parts of the overall consumption. Data is corrected for climate in a way that takes the differences in feasibilities in the different climates into account.

The following questions were used to support the assessment:

- Does the code set an overall energy performance frame for buildings?
- Does the code prescribe mandatory computer modelling in order to ascertain the expected performance of a building?
- How high is the maximal energy end use (kWh/m2 or Btu/ft2 per year)?

Primary Energy

This criterion assesses the total performance of the building code in primary energy. The assessment can be based directly on the demands in the code if these are set based on final energy use performance values and including most all parts buildings primary energy use. Where energy demands are prescriptive or exclude major building energy use, final values will be calculated. Data is corrected for differences in climates based on a model, which also address differences in cost efficiency for energy saving measures.

The following questions were used to support the assessment:

- Does the code set an overall performance frame for buildings?
- Is this based on primary energy use?
- Does the code prescribe mandatory computer modelling in order to ascertain the expected performance of a building?
- How high is the primary energy end use (kWh/m2 or Btu/ft2 per year)?

GHG Emissions

This criterion assesses the demands on environmental performance (GHG emission) of the building energy efficiency code. This assessment is based directly on the demands for GHG emission in the energy efficiency code and includes all parts of the building related energy use. If these are set based on energy performance values, with clear criteria's for GHG emission it can be based on a calculated value taking into account all above elements. Data is corrected for differences in climates based on a model, which also address differences in cost efficiency for energy saving measures.

The following questions were used to support the assessment:

- Does the code set an overall performance frame for buildings (kWh/m2 per year)?
- Does the code have a maximal energy performance and does it take GHG emission factors into account?
- How high is the maximal GHG emissions energy (tons/m2 per year)?
- Does the code take life cycle analysis into account?

APPENDIX TWO – SCORING MATRICES

THEME 1:	HOLISTIC APPROACH	SCORE
Criterion 1:	**Performance Based Approach**	
	Does the code set an overall performance frame for buildings (kWh/m2 per year)?	5
	Does the code take primary energy use, GHG emissions or peak loads into account?	2
	Does the calculation take passive heating, passive cooling, natural ventilation, natural light and shading or other natural elements into account?	1
	Does the code actively encourage integrated or bioclimatic design of buildings?	1
	Does the code have a clear definition of building performance?	1

THEME 1:	HOLISTIC APPROACH	SCORE
Criterion 2:	**Performance to include all energy**	
	Do the requirements include most of the energy consumption in a building (i.e. heating cooling, ventilation and dehumidification)?	2
	Does the performance include domestic hot water?	2
	Do the requirements include lighting requirements?	2
	Does the code include energy consumption such as elevators, appliances and pumps and fans?	2
	Does the code include conversion and transportation losses?	2

THEME 1:	HOLISTIC APPROACH	SCORE
Criterion 3:	**High energy performance and use of passive/active renewable energy**	
	Does the code significantly reduce energy needs for instance by setting requirements for the buildings efficiency and renewable energy?	0
	Does the code require/strongly encourage efficient use of passive heating and passive cooling?	2
	Does the code require/strongly encourage natural ventilation?	2
	Does the code require/encourage for daylight use?	2
	Does the code require/encourage for shading?	2
	Does the energy performance require/encourage a reduction for energy provided by renewable energy systems?	2
	Does the code include Life Cycle Assessment?	0

THEME 2:	DYNAMIC CODES	SCORE
Criterion 4:	**Zero Energy Target for the Future**	
	Has the path to ZEB performance/compliance been clearly set out for the future?	3
	Are there binding targets based on a roadmap, which are achievable, realistic and relevant to the country/region and state of the market? Are there aspirational targets for revisions towards zero energy?	2
	How quickly will a target for reaching net zero energy buildings be achieved (for instance by 2020 or 2030 been set)? Is this realistic given the actual state?	3
	Are all end uses included in this target?	2

THEME 2:	DYNAMIC CODES	SCORE
Criterion 5:	**Regular and Frequent Revision Cycles**	
	Does the code have regular and frequent revision cycles (max 3-5 years)? Has this process been followed in the past?	4
	Are key stakeholders involved in the development of new requirements? Is the development of the code followed by training activities?	2
	Does code adoption take life cycle assessment into account? Are the requirements supporting a dynamic and ambitious development of codes by including economic rational and other benefits?	2
	Does the code or other legislation have aspirational targets for the future revisions that have already been defined? Are targets clearly set out and well defined at least 2- 3 years in advance?	2

THEME 2:	DYNAMIC CODES	SCORE
Criterion 6:	**Levels or encouragement to go beyond minimum standard**	
	Does the code and complementing policies encourage buildings to go beyond minimum requirements?	4
	Is this well documented for instance by certification schemes introducing well defined classes "above standard level"?	2
	Can the code 'stretch' or 'reach' beyond minimum requirements and reward buildings that achieve significant savings on standard design? Does the code have low energy classes, Code -20%, -30% or -50 %?	2
	Are there any special requirements for public buildings to pave the way for the rest of the market and to demonstrate best practices and BAT measures?	2

THEME 3:	IMPLEMENTATION	SCORE
Criterion 7:	**Good Enforcement**	
	Is the code clearly mandatory rather than voluntary or semi-voluntary?	0
	Is there a clearly defined and robust control and verification system for assessing compliance? Does this necessitate onsite inspections during and after the construction process and is post-occupancy control included?	2
	Does the code require post occupancy energy verification?	2
	Are strong penalties for lack of compliance frequently enforced?	1
	Are surveys independently conducted on compliance rates and do they demonstrate a high rate of compliance?	3
	Are there adequate provisions for training of inspectors and is their work quality controlled?	1

THEME 3:	IMPLEMENTATION	SCORE
Criterion 8:	**Certification to support codes**	
	Is building energy efficiency certification mandatory in all new buildings?	4
	Is it a positive labelling for a defined level of building going beyond the minimum?	2
	Will the result of assessment influence final compliance approval?	3
	Is the certification system robust and well integrated in the process?	1

THEME 3:	IMPLEMENTATION	SCORE
Criterion 9:	**Policy packages supporting codes**	
	Is there a system of rating or labelling for major building components?	2
	Are there any special incentives or requirements for public buildings to pave the way for the rest of the market?	2
	Does the code link to and support stricter standards such as green buildings, passive houses, integrated design or bio-climatic design.	2
	Are there supporting measures, which increase energy efficiency and or allow minimum requirement levels to be exceeded? (E.g. reduced property tax, higher incentive, better loan conditions, grants, etc.)	2
	Are there education systems to ensure capacity in all parts of the construction sector?	2

THEME 4:	TECHNICAL/INDIVIDUAL REQUIREMENTS	SCORE
Criterion 10:	**Energy demands on building shell**	
	Does the building code stipulate low maximum u-values for the most important building parts (at least walls, floors, roofs, windows/skylights and doors)	4
	Does the code stipulate low maximum psi-values or is thermal bridging included in the building envelope calculation?	2
	Are the u-values established relevant to the climate?	2
	Does the code require a strict level of air-tightness including testing?	2

THEME 4:	TECHNICAL/INDIVIDUAL REQUIREMENTS	SCORE
Criterion 11:	**Technical systems**	
	Does the code require efficient and well-designed HVAC systems?	2
	Does the code require overall efficiency testing of technical systems? Does this include pressure testing of ducting systems when needed?	2
	Is commissioning a requirement of the code?	1
	Does the code include airtightness requirements?	1
	Does the code require heat recovery systems to be implemented when possible?	2
	Do the requirements address efficiency of lighting installations?	1
	Does the code require minimum efficiency levels of domestic hot water?	1

THEME 4:	TECHNICAL/INDIVIDUAL REQUIREMENTS	SCORE
Criterion 12:	**Renewable energy systems**	
	Does the code have separate requirements for use of active renewable energy? Does the total performance include active renewable?	5
	Does this include all types of buildings?	2
	Are the demands stringent (highest demand will get three points (3,2,1,and 0))?	3

THEME 5:	OVERALL PERFORMANCE OF THE CODE	SCORE
Criterion 13:	**Overall performance/on-site (low and getting lower)**	
	Does the code set an overall energy performance frame for buildings?	
	Does the code prescribe mandatory computer modelling in order to ascertain the expected performance of a building?	
	How high is the maximal energy end use (kWh/m^2 or Btu/ft^2 per year)?	

THEME 5:	OVERALL PERFORMANCE OF THE CODE	SCORE
Criterion 14:	**Overall performance/primary energy (low and getting lower)**	
	Does the code set an overall energy performance frame for buildings?	
	Is the code based on primary energy use?	
	Does the code prescribe mandatory computer modelling in order to ascertain the expected performance of a building?	
	How high is the maximal energy primary energy end use (kWh/m^2 or Btu/ft^2 per year)? How high is the maximal energy primary energy end use (kWh/m^2 or Btu/ft^2 per year)	

THEME 5:	OVERALL PERFORMANCE OF THE CODE	SCORE
Criterion 15:	**Overall performance/GHG emissions (low and getting lower)**	
	Does the code set an overall environmental performance frame for buildings (kWh/m2 per year)?	
	Does the code have a maximal energy performance and take GHG emission factors into account?	
	How high is the maximal GHG emission energy (tons/m2 per year)?	
	Does the code take LCA into account?	

APPENDIX THREE – CLIMATE COMPARISON

The climate model contains four climate zones defined as follows:
Heating Based Climate: HDD ≥ 2 × CDD
Cooling Based Climate: CDD ≥ 2 × HDD
Mixed Climate: HDD/2 < CDD < 2 × HDD
Warm and Humid: As defined in the regional or national codes

Codes were arranged in the model as follows:

Table 3.0 Climate Model

Heating Based	**Cooling Based**	**Mixed**	**Hot & Humid**
Austria	City of Austin	NSW - BASIX	Singapore
	China - (Hot Summer/Warm Winter)	China Public (All of china)	
China - (Severe Cold/Cold)	India - ECBC	California	
Denmark			
Ireland			
Finland			
France			
Germany			
Lithuania			
Maryland			
Massachusetts			
Netherlands			
NYC			
Oregon			
Ontario			
Spain			
Seattle			
Sweden			
England &Wales			

Baseline data on the average heating degree days (HDD) and cooling degree days (CDD) for a number of cities in each of the building code jurisdictions was collected. Where there were multiple climates within a jurisdiction, cities were chosen from the most densely populated areas in the jurisdiction or region. The averages were calculated over a five-year period with a base temperature of 18 degrees Celsius for the calculation of both HDD and CDD[2]. The average values for each of the cities were combined to create a jurisdictional average. An average of the combined HDD and CDD was also calculated for each jurisdiction or for individual locations inside this jurisdiction allowing for comparison of codes also across different climate types. The building codes were then divided into the three climate zones based on the jurisdictional average. Consideration was also been given to humidity levels.

---

[2]Bizee Degree Day software (www.degreedays.net) was used for this calculation

Global Buildings Performance Network

Building Policies for a Better World

GBPN
Global Buildings Performance Network

9 rue du Quatre Septembre
75002 Paris
France

+33 (0)1 70 98 31 30
info@gbpn.org

www.gbpn.org
@GBPNetwork

About GBPN The Global Buildings Performance Network (GBPN) is a globally organised and regionally focused network whose mission is to advance best practice policies that can significantly reduce energy consumption and associated CO_2 emissions from buildings.