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DIPLOMARBEIT

EEI energy efficiency improvement. A comparison of the development of policies in relation to the energy efficiency of residential building stock, between Germany and China.

This thesis provides the groundwork for a prediction of policy adjustment that will raise energy saving potential in residential building stock in China and Germany.

ausgefürt zum Zwecke der Erlangung des akademischen Grades eines
Diplom-Ingenieurs / Diplom-Ingenieurin
unter der Leitung

Ass. Prof. Arch. Dipl.-Ing. Dr.techn. Mladen Jadric

E253-4

Institute Hochbau 1, Architektur & Entwerfen

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Fakultät für Architektur und Raumplanung

von

Justus A. Wünsche

0728555

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Candidate:	Justus A. Wünsche
Student Number Tongji:	1237096
Student Number TU Wien:	0728555
School/Department Tongji:	College of Architecture and Urban Planning
School/Department TU Wien:	Fakultät für Architektur und Raumplaung
Discipline	Architecture
Major:	Architecture
Supervisor Tongji:	Prof. Yongjie Cai Phd
Supervisor TU Wien:	Ass. Prof. Arch. Dipl.-Ing. Dr.techn. Mladen Jadric

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EEI能源效率提高 – 德国和中国

与住宅建筑存量相关的能源效率策略发展比较

以提高中国和德国在住宅建筑存量的节能潜力, 本论文提供了预测中德政策调整的基础

研究生: **希望**
同济大学学号: 1237096
维也纳科技大学学号: : 0728555
同济大学所在院, 系: 建筑与城市规划学院
维也纳科技大学所在院, 系: Fakultät für Architektur und Raumplaung
专业: 建筑
专业: 建筑
同济大学导师: Prof. Yongjie Cai Phd
维也纳科技大学导师: Ass. Prof. Arch. Dipl.-Ing. Dr.techn. Mladen Jadric

2015年11月

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ABSTRACT

China has a tremendous fast growing economy and a rapid growing building stock rate, with approximately 43 billion m^2 of residential buildings in 2015, representing almost twice the total existing building areas in the European Union. Residential and commercial buildings are accounted for nearly one third of the worldwide final energy consumption in 2010, which brings about significant actions to mitigate energy consumption and reduction of CO_2 emissions on a global level. Political sanctions for the improvement of the rising number of new buildings and accelerating the retrofitting of the huge aged building stock are indispensable.

Germany, being part of the European Union, with its ambitious energy reduction objectives, long-term history in energy efficiency codes, as well as its similar historical development of the industrialization (Wirtschaftswunder), is an exemplary base case itself for the evaluation of Energy Efficient Improvement (EEI) effectiveness and predictions for future scenarios, for both countries.

This thesis is concerning the effectiveness of energy policies in China and in Germany. Are there any possibilities to implement energy policies more aggressively in order to accelerate the development to build new energy efficient buildings and to retrofit existing buildings in a more energy efficient way? There will be a comprehensive analysis of building energy efficiency policies, building codes, monitoring-, labeling- and incentive programs and their effectivity in the form of a comparison between China and Germany - the energy performance of their residential building stocks with respect to the economic growth, living standards and climate conditions in the two studied countries.

For China as well as for Germany, this paper will analyze the actual policy structure and its provision in building codes, mandatory and voluntary programs, labelling systems of energy efficiency and incentives, in order to evaluate the program performances and to predict possible suggestions for improvement as well as future scenarios.

The pivotal point in the process of EEI is that there are a many parties involved, such as politicians, developers as well as owners, who decide what happens with and in these concerned buildings. It is crucial to provide policy makers the groundwork to better understanding these factors, which will affect the decisions to design more effective policies to promote EEI.

Key Words: energy policy, building codes, residential building stock,

China, Germany, retrofit

.

KURZFASSUNG

China hat ein enormes Wirtschaftswachstum und einen stark wachsenden Gebäudebestand. Mit rund 43 Milliarden m^2 Wohnnutzfläche im Jahr 2015, repräsentiert China fast das Doppelte der gesamten Wohnnutzfläche der Europäischen Union. Wohn- und Geschäftsgebäude stellten fast ein Drittel des weltweiten Endenergieverbrauchs im Jahr 2010 dar. Was die Notwendigkeit darlegt, den Energieverbrauch und CO2-Emissionen auf globaler Ebene zu minimieren. Politische Sanktionen zur Verbesserung der wachsenden Neubauzahlen und zur Beschleunigung der Renovierung des alternden Gebäudebestands sind unabdingbar.

Deutschland, als Teil der Europäischen Union, mit seinen ehrgeizigen Energieeinsparungszielen, langzeitigen Geschichte in Sanktionen zur Steigerung der Energieeffizienz, sowie der ähnliche wirtschaftlichen Entwicklung im Zuge der Industrialisierung (Wirtschaftswunder), stellt einen vorbildlichen Base Case zur Bewertung von Energie Effizienten Verbesserungsmaßnahmen (EEI) dar. Als auch als Abbild der Effektivität sowie Prognosen für zukünftige Verbesserungs-Szenarien für beide Länder.

Diese These evaluiert die Wirksamkeit der Energiepolitik in China und in Deutschland. Es wird erörtert, ob es Möglichkeiten gibt, die Energiepolitik offensiver umzusetzen, um die Entwicklung, neue Gebäude energieeffizienter zu bauen und bestehende Gebäude in einer energieeffizienteren Weise nachzurüsten zu beschleunigen? Dies wird in form einer umfassende Analyse von Gebäudeenergieeffizienzpolitik, Bauvorschriften, Kontrollinstanzen-, Zertifizierung- und Förder-Programmen evaluiert. Im Weiteren wird die Gesamtenergieeffizient des Wohngebäudebestandes von China und Deutschland unter Betracht von Wirtschaftswachstum, Lebensstandards und der klimatischen Bedingungen in den beiden Ländern untersucht.

Für China als auch für Deutschland, wird die aktuelle politische Struktur, Regelung der Bauvorschriften, verpflichtende- und freiwillige Programme zur Kennzeichnung der Energieeffizienz sowie Förderungsprogramme auf ihre Effizienz analysiert, um diese zu bewerten und mögliche Verbesserungsvorschläge für Zukunftsszenarien geben zu können.

Dreh- und Angelpunkt im Prozess der EEI ist, dass viele Interessenvertreter, wie Politiker, Entwickler sowie Eigentümer involviert sind, welche mitentscheiden, was mit den betroffenen Gebäuden geschieht. Es ist essentiell, politischen Entscheidungsträgern die Grundlagen zum besseres Verständnis dieser Faktoren zu liefern, um künftige politische Entscheidungen zur Förderung von EEI effizienter gestalten zu können.

Key Words: Energiepolitik, Bauordnung, Wohngebäudebestand,

China, Deutschland, Sanierung

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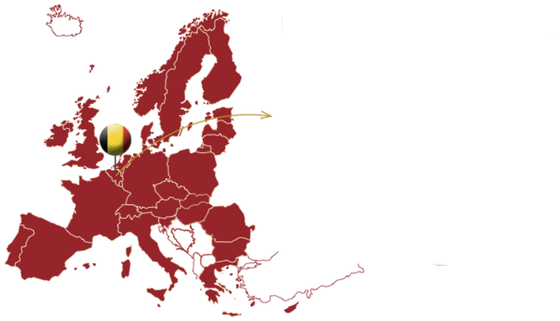
This work is dedicated to them.

INDEX

TABLE OF CONTENT

1. Introduction

The objective of this work is to evaluate if there are possibilities how energy policy can be justified and implemented more powerful, in order to accelerate the development to build new buildings and to retrofit existing buildings in a more energy efficient way? It is necessary to provide the groundwork for policy makers for future code revisions and adjustments.



	Population (2010)	Land area (km²)	Building Floor Space
EU27	501 million	4 324 782	24 billion m²
US	309 million	9 826 675	25 billion m²
China	1 338 million	9 598 080	35 billion m²

In order to represent an accurate picture of the needs and possibilities in this sector, we have chosen Germany as the comparison with China as it is one of the biggest and densest countries in the European Union.

Surprisingly and to further strengthen this choice, Europe has the highest 'building density' (building floor space over land area, see Fig. 01) compared to China and the US. [1]

Figure 01: Building gross floor space in the EU27, incl. Switzerland and Norway
Source: [2]

This comparison is still valid in 2015 - Germany only has an average growth rate of 1.2%. [3] and the fast and tremendous growth rate of China´s economy and building stock evaluates the total building stock of China's residential buildings at 43 billion m^2 in 2015.

Depending on climate, population and economic characteristics, the human factor as an end-user with its habits has a great impact on the final energy consumption of a country. In 2010, energy services delivered in residential and commercial buildings accounted for about one third of the worldwide final energy demand and carbon dioxide (CO2) emissions. As shown in Figure: 02, in China, the total energy demand in residential buildings tripled since 1996 to 2008.

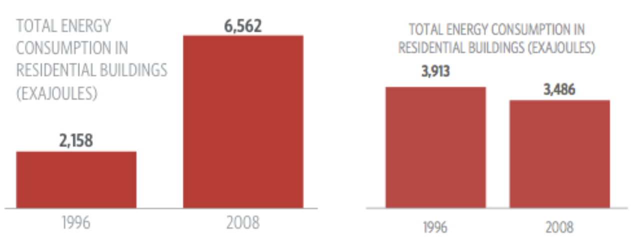


Figure 02: Total energy consumption in residential buildings
Source: [4]

It should be noted that energy-related behaviours in commercial buildings are different from those in residential buildings. [5]

[1] Marina Economidou et al., "Europe's Buildings under the Microscope" (Buildings Performance Institute Europe (BPIE), 2011), 27.
[2] World Bank, Eurostat, 2011 in ibid.
[3] Mark Levine et al., "BUILDING ENERGY EFFICIENCY: BEST PRACTICE POLICIES AND POLICY PACKAGES" (Global Buildings Performance Network, 2012), 95.
[4] Hermann Amecke et al., "Buildings Energy Efficiency in China, Germany, and the United States," 2013, 10&15, http://www.ccrasa.com/library_1/23291%20-%20Buildings%20Energy%20Efficiency%20in%20China%20Germany%20and%20the%20United%20States.pdf.
[5] Boqiang Lin and Hongxun Liu, "CO2 Emissions of China's Commercial and Residential Buildings: Evidence and Reduction Policy," *Building and Environment* 92 (October 2015): 425, doi:10.1016/j.buildenv.2015.05.020.

At the moment there is no recent review of the worldwide potential for energy efficiency improvement (EEI). Analysts indicate that about 29% of global baseline buildings CO2 emissions could be eliminated by 2020, with investments that pay for themselves through the reduced energy costs. In other words, the largest part of these CO2 emissions could be reduced through implementation of energy efficiency technologies. (Levine, 2007Levine, 2007)

Inefficient and badly constructed buildings lead to higher energy consumption, lesser thermal comfort, higher or lower humidity levels, wrong dew-point levels, and cause therefore a significant impact on the environment, on construction durability, on the economy, as well as in some cases on the resident´s health. (Zhang and Yoshino, 2010)

The main challenges and difficulties of EEI are the different policy frameworks associated to climate characteristics and economic growth. As mentioned above, the total energy consumption in residential buildings in China tripled since 1996 to 2008. The counter draw is Germany, where it is decreasing, which is a document of energy policy success and a note to the potential energy savings in China and still in Germany, associated with the installation of energy efficiency technologies by adjusting and improving energy policies.

The well-documented close relationship between GDP growth and fossil energy use with its attendant carbon emission indicates that the emergence of a country as a major economic power cannot occur without an increased energy consumption and concomitant carbon emission. However, for instance, such investments in EEI can lead to an improved living comfort, mentioned above (insulated buildings protect better from cold or hot outside temperatures) as well as a decrease in indoor air pollution [1]. Furthermore, investments in energy efficiency in buildings also improve the aesthetics of a building, extension of lifecycle, increasing the value of the asset and raising the construction demand [2] and hence creating new jobs in the construction sector, as well as the manufacturing sector [3].

Due to these facts of large energy consumption and huge CO_2 emissions, the building sector plays a major role in dealing with global objectives in relation to Energy Efficiency Policies [4]. Furthermore, a potential change will soon take place in China, where the rethinking of the urban redevelopment of the existing cities will occur, and has partly started already. [5].

This paper illustrates the German development of energy policy and its effects compared to China, which depict a potential future scenario for both countries.

1 Carmen Richerzhagen, *Energy Efficiency in Buildings in China: Policies, Barriers and Opportunities*, Studies (Deutsches Institut Für Entwicklungspolitik) 41 (Bonn: German Development Institute, 2008), 30.
2 Economidou et al., "Europe's Buildings under the Microscope," 27.
3 Bin Shui and Jun Li, "Building EE Policies in China, Global Uilding Performance Network," Status Report (American Council for Energy-Efficient Economy, 2012), 53, http://aceee.org/sites/default/files/publications/researchreports/e129.pdf.
4 Lin and Liu, "CO2 Emissions of China's Commercial and Residential Buildings," 428.
5 Lin Cai, "Strategien der Stadterneuerung in China am Fallbeispiel Yangzhou" (Technische Universität Berlin, 2011), 53.

2. Literature Review

Aside from architectural aesthetics and its design value, buildings play an important role in our lives and societies - they define our daily work behavior and living settings, our urban space and surrounding environment. Beside the spatial quality, function and use, a healthy indoor and outdoor climate should be a basic requirement.[1]

In China as well as in most EU countries, the energy performance of existing buildings is generally poor until now. The old buildings represent the vast majority of the poor-energy performance level building stock and the new buildings are constructed with high-energy performance levels.[2] In China as well as in Germany, the building sector consumes approximately one third of the overall national energy consumption.[3] Improving the renovation work on existing buildings is therefore of an urgent interest in both countries.

Countries like China and other developing countries are expected to account for 80% or more of the growth in building energy use worldwide in the coming decades. The potential to cut emissions as much as all other energy-using sectors combined can be reached by the emissions reductions of energy efficiency in buildings on one hand, and conservation of energy in buildings on the other hand. As a result, the largest opportunity to mitigate climate change is constituted by buildings, which is especially the case in developing countries.[4]

It is a complex process to achieve these potentials. Therefore, a substantial understanding of several characteristics of the building stock needs to be acquired by policy makers in this field. It is essential to understand what affects people´s decision-making processes, the impact of current policies as well as the key characteristics of the building stock etc. to enable the development of effective policies with energy efficient improvements as a resulting consequence.[5]

There is a huge amount of literature in this field of research, whereof in the following, a short overview of the main used literature will be illustrated:

"Europe's Buildings under the Microscope"

Economidou, Marina, Bogdan Atansasiu, Chantal Despret, Joana Maio, Ingeborg Nolte, and Oliver Rapf // Buildings Performance Institute Europe (BPIE), 2011.

This work focus mainly on the European Union and shows a very detailed picture about the actual building stock - its typology in terms of shares of residential and commercial buildings, building size and its age condition as well as its distribution and energy performance in each category and country. It further illustrates the difficulties regarding ownership and tenure circumstances. The main body of this work concerns the effects after setting up the Energy Performance Buildings Directive (EPBD) and its regulatory and legislative framework, implementation and recasts. The main provisions and reviews of the EPBD and its effects in all member states of the EU is analyzed in detailed. Overall, it is an in-depth analysis of the European building stock, but unfortunately without a comparison to other countries with similar characteristics and circumstances. The current work attempts to close this gap with a comprehensive comparison between China and Germany.

[1] Economidou et al., "Europe's Buildings under the Microscope," 07.
[2] Ibid.
[3] Greenovation Hub and Germanwatch, eds., "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study -" (Greenovation Hub and Germanwatch, 2012), 07, https://germanwatch.org/en/download/8546.pdf.
[4] Levine et al., "BUILDING ENERGY EFFICIENCY: BEST PRACTICE POLICIES AND POLICY PACKAGES," 21.
[5] Economidou et al., "Europe's Buildings under the Microscope," 07.

“Buildings Energy Efficiency in China, Germany, and the United States”

Amecke, Hermann, Jeff Deason, Andrew Hobbs, Aleksandra Novikova, Yang Xiu, and Zhang Shengyuan, 2013

This report compares the energy efficiency policy in China, Germany and the United States in order to review policy effectiveness and to present challenges and opportunities of the following analyzed categories: new construction, building retrofit, building equipment and operations. Out of which, operations was not evaluated as there is no data available yet. The paper focuses mainly on the energy consumption of the compared building stocks, with a differentiation between commercial, urban residential and rural residential buildings in the actual state of the report, with a retrospect back dated to 2000 and future estimations till 2030. Climate and energy economics are touched on as well as parts of emission. A detailed analysis and differentiation of the specific building regulation framework and how it works, is not illustrated. The current work attempts to close this lack in points of a detailed evaluation and comparison of the two different policy frameworks.

“Energy efficiency: Best practice policies and policy packages.”

Levine, Mark, Stephane de la Rue De Cane, Nina Zheng, and Christoper Williams.

Global Buildings Performance Network, 2012.

This work analyzes four countries, the United States, European Union, China and India, in the following areas: the energy use in buildings, building energy codes and framework, energy labelling and incentive programs. It offers a wide and very specific overview of the above-mentioned items in respect to differentiation between typologies, climate issues as well as market differences. Furthermore, it presents recommendations of “best practices”, for each country. There are argumentations between the analyzed countries and its specific outcomes and needs, but detailed comparison and discussion between certain analyzed countries is not available. The current work differs between China and Germany, because of its similar historical development in the above mentioned areas in detail and is trying to conclude those points.

The current work in hand presents a comprehensive investigation and comparison of both countries, China and Germany, in terms of residential building stock, building code framework, policy structure as well as control systems and incentive programs. Considering both countries’ climate and economic history and present conditions, Germany, being part of the European Union, and closely matches China in the above-mentioned factors has been chosen.

The outcome should provide politicians and decision makers, the groundwork for future reviews and adjustments for policy effectiveness, as well as supplying better understanding of the factors that will affect the development and the structure of each building stock.

3. Background

3.1. GEOGRAPHICAL DIFFERENCES BETWEEN CHINA & EU

Energy Efficient Improvement EEI depends on many environmental factors, illustrated in the following, especially in factors such as size, population density and climate zones.

CHINA

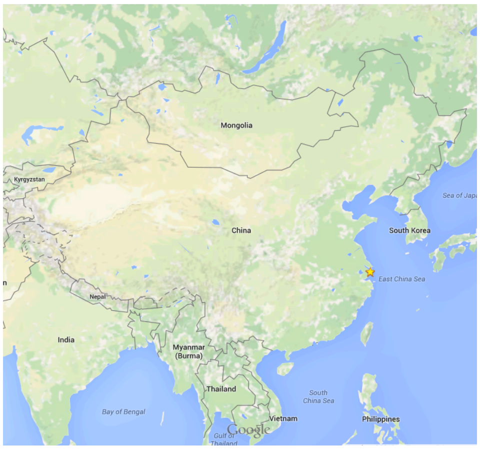


Fig. 03: China map
Source:[2]

China is the fourth largest country in the world, at 9.596.960 km^2, after Russia, Canada and the United States of America.

China is located to the East of the Asian continent and covers, with it´s 22 provinces, almost a quarter of its surface.

Between North Korea and Vietnam, China is bordering the East China Sea, Korea Bay, Yellow Sea and South China Sea. China extends from 18 ° to 54 ° North latitude and from 71 ° to 135 ° East longitude with high plateaus, mostly mountains with hills in the East, deserts in the West, plains and deltas. [1]

EU & GERMANY

Figure 04: European map
Source:[5]

The European Union´s area is 4.324.782 km2 and is less than half the size of China.[3]

Germany is located in Central Europe and after France, Spain and Sweden, Germany - at 357.022 km2 - is the 4th largest member of the 28 member states in the European Union.
Germany consists of sixteen provinces, bordering the North, East and the Baltic Sea between Netherlands, Denmark and Poland. Germany extends from 6° to 15° East longitude to 47° - 55° North latitude with lowlands in the North, uplands in the center and the Bavarian Alps in the South. [4]

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[1] “China Provinces,” August 25, 2015.
[2] “150829 Map China Climate.jpg,” n.d., http://www.pacificbulbsociety.org/pbswiki/files/Maps/ChinaHZMap.pdf.
[3] “CIA Online Version,” Database, (August 18, 2015), 1.1.1.https://www.cia.gov/library/publications/resources/the-world-factbook/geos/ch.html.
[4] Ibid.
[5] “150829 Map Europe Climate.jpg,” n.d., http://www.backyardgardener.com/zone/europe1zone.html.

As mentioned above, the EU is only almost half the size of China. Corresponding to the geographical size, Germany is almost the same size as China´s Henan province (167.000 km^2) and Shandong province (153.800 km^2) together, where we will refer to later in this report.

3.2. CLIMATE DIFFERENCES & REQUIRED NECESSITIES

Climate conditions have one of the biggest impacts on energy consumption on building equipment, e.g. space heating and air conditioning demand [1].

CHINA

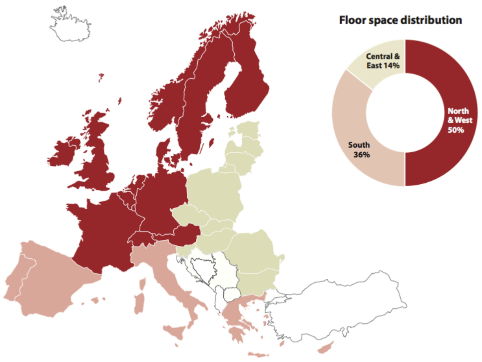
Covering East Asia from north-south and east-west, China´s climate ranges from sub-arctic in north-eastern Manchuria to tropical in southern Hainan province. China can be indexed into five climate zones:

Severe Cold	-10C to <25c
Cold	-10C / 18-28C
HSCW	0-10C / 25-30C
HSWW	>10C / 25-29C
Temperate	0-13F / 18-25C

[2]**Figure 05: China Climate map**
Source: [3]

This wide spectrum of heat and cold includes a wide range of varying humidity levels and is therefore causing very different requirements to the building equipment. Northern areas are mostly heated by district heating systems, whereas the southern parts require cooling systems and hardly any heating. In the residential sector of rural areas, the traditional methods of climate control and cooking are dominating: the substantial energy is generated by the combustion of biomass like straw and fuel or wood. [4]

EU & GERMANY



For analytical reasons for this study, the European Union including Germany is divided based on climatic and building typology similarity regions:

Namely North&West (NW) / South (S) and Central&East (CE). [5]
NW = very cold zone (>4000 HDD)
CE = moderately cold zone (2500-4000 HDD)
S = warm zone (ca. 2500 HDD)[6]
Figure 06: European Climate map
Source: [7]

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[1] Amecke et al., "Buildings Energy Efficiency in China, Germany, and the United States," 9–11.
[2] Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study - ," 11.
[3] "150829 Map China Climate.jpg."
[4] Amecke et al., "Buildings Energy Efficiency in China, Germany, and the United States," 9–11.
[5] Economidou et al., "Europe's Buildings under the Microscope," 28.
[6] Levine et al., "BUILDING ENERGY EFFICIENCY: BEST PRACTICE POLICIES AND POLICY PACKAGES," 46.
[7] "150829 Map Europe Climate.jpg."

Germany's climate is defined by warm summers and cool and wet winters and does not have notable climate zones.

Buildings are generally heated by space and floor heating. The demand for cooling is very low due to the cool climate and cultural preference for natural ventilation. [1]

> **Germany´s continental climate and the required needs are comparable with the region of Henan and Shandong province located in the HSCW zone.**

As mentioned above, China is divided into 5 climate zones and the German regions have similar characteristics to the HSCW zone (hot summer cold winter) of Henan and Shandong province. In the past, these buildings in China did not have any heating nor cooling systems. But today, the energy used for heating purposes in residential buildings in Northern China was 2-3 times more than that of countries in similar climatic regions of Western Europe. [2]

3.3. DEMOGRAPHICAL DIFFERENCES BETWEEN CHINA & EU

The main causes of regional differences in population growth are the migratory movements. Economically strong and predominantly urban regions benefit from inflows from rural and peripheral areas as well as from immigrants from abroad. These regions offer a "high quality of life" because of their wide range of jobs, educational institutions as well as leisure and shopping facilities.[3]

CHINA

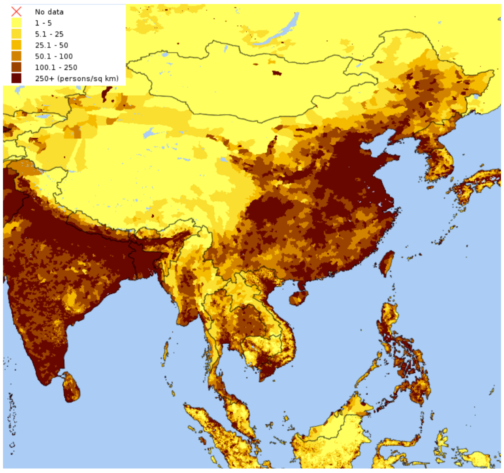

Figure 07: China demographical map
Source: [5]

China is the most populous country in the world: 20% of the Earth´s population resides in China, totaling to more than 1.37 billion people in 2015. The continuous urbanization is leading an incessant flow of immigrants into the cities; slightly more than 50% of the population lives in cities, which are mainly located at the seaside and river systems. [4] This is expected to continue, driven by the influx of an estimated 350 million people into cities over the next 20 years. According to official statistics, the number of cities increased from 193 in 1978 to 655 in 2007. While the number of cities grew, the urban areas as well as the population increased as well.

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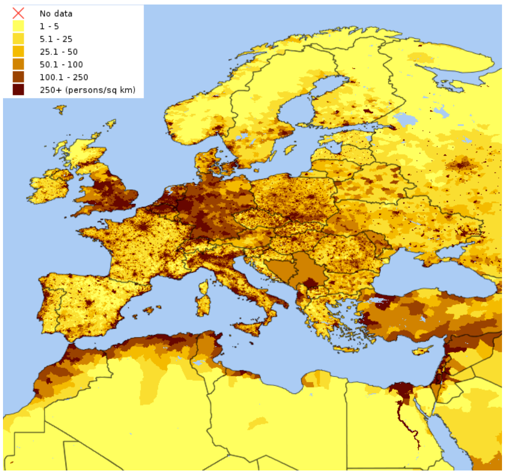
[1] Amecke et al., "Buildings Energy Efficiency in China, Germany, and the United States," 14.
[2] Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study - ," 14.
[3] "Demografie-Portal," August 18, 2015, http://www.demografie-portal.de/SharedDocs/Informieren/DE/ZahlenFakten/Bevoelkerungswachstum_Kreise_Prognose.html.
[4] Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study - ," 11.
[5] "150827 Map China Demogr.png," accessed August 26, 2015, http://sedac.ciesin.columbia.edu/maps/client.

EU & GERMANY



[1]

Respective to the areas defined in Chapter 2.2, over half of the population live in the NW area, distribution as follows:

NW 281 million
CE 102 million
S 129 million

Germany is one of the densest EU-countries even if its population has been declining since 2003. According to the current regional planning forecast, the population will shrink from 80.5 millions in 2012 to 78.2 millions in 2035, a decrease of 3%.

Figure 08: Europe demographical map
Source:[2]

However, the development is regionally very different. Economically strong regions will continue growing, like Munich with its expected 22% as the region with the strongest growth quota. In contrast, the population is decreasing sharply in structurally weak areas, particularly in eastern Germany. [3]

[1] Economidou et al., “Europe’s Buildings under the Microscope,” 28.
[2] “150827 Map Europa Demogr.png,” accessed August 26, 2015, http://sedac.ciesin.columbia.edu/maps/client.
[3] “Demografie-Portal.”

4. DEVELOPMENT OF THE BUILDING STOCK

China´s changes in policy, economy and social conditions are the results of a 30-year-old process that started with the reforms and opening up in 1978. But the rapid economic growth also results in an excessive use of resources, social tensions between different population groups, as well as the loss of the historical and cultural identity due to the fast growing building stock with its focus on new buildings instead of conservation and retrofit. As in Germany, China´s urban regeneration and its challenges have evolved in the last decade and has become an important field of innovative search for new solutions and methods. A turnaround like in Germany at the end of the 1960s, with focus on maintenance, repair and careful modernization of existing old buildings and entire residential neighbourhoods, has not taken place in China yet. Despite China´s gentle approaches to the refurbishment, the aerial redevelopment still constitutes the overwhelming remediation area strategy. [1]

4.1. CURRENT STATUS OF THE BUILDING STOCK

CHINA

In 2010, China´s urban existing building stock was approximately 48.6bn m^2, 38.7% [2] (represents 38.7% of the total building stock). China has a fast growing building stock with an average growth rate of 1.7bn m^2 of new floor area each year between 2000 and 2010, illustrated in Fig. 09 [3]. It is estimated that China will add a further four to five billion square meters of new buildings in urban areas between 2015 and 2020 [4]. More than half the population is already living in urban areas, as mentioned in Chapter 3.3, and the floor space used per person (in urban residential buildings) doubled from 11m^2 to 22m^2 (China Statistical Yearbook 1997-2010, cited in Schroeder/Guo, unpublished draft). An estimation of growth to 46 m^2/per person is expected. As a result, the expected total residential floor space would reach 51 billion m^2 in 2050 [5], which will mean a tremendous and impactful building boom and urban growth for China.

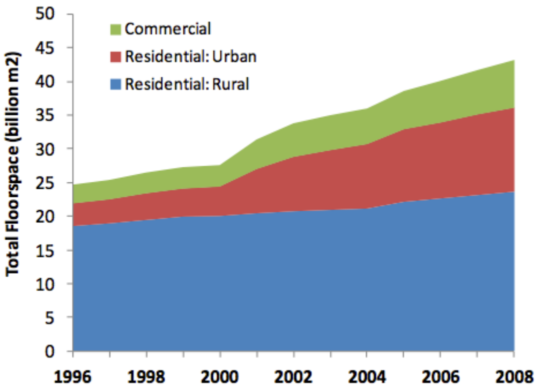


Figure 09: China´s Reported Historical Total Floor Space by Building Type, 1996-2008
Source: [6]

The estimated influx into cities is expected with 350 million people in the next 20 years [7].

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[1] Cai, "Strategien der Stadterneuerung in China am Fallbeispiel Yangzhou," 7.
[2] Shui and Li, "Building EE Policies in China, Global Uilding Performance Network," 12.
[3] Ibid., 34.
[4] MOHURD 2012 in Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study -," 15.
[5] LBNL in Mark Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 94, http://escholarship.org/uc/item/5206n1xr.pdf.
[6] Ibid.
[7] Worldbank, 2012 in Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study -," 11.

According to the continuous rapid urbanization and economic growth, buildings become an increasingly important consumer of energy. Together with the urbanization process, the energy demand in buildings has risen strongly, with the final energy consumption increasing by 175% between 1990 and 2005, see Fig. 02&10 [1].

Regarding to its size and wide climate range, China is separated into five different climatic zones, as illustrated in Chapter 3.2. The situation of the building sector differs greatly between Northern and Southern China, as well as between rural and urban areas. Hence, the building sector's energy consumption is generally classified into four categories: (1) energy consumption for heating in northern urban buildings; (2) energy consumption of urban residential buildings (except heating in the north); (3) energy consumption in public buildings (except heating in the north); and (4) energy consumption of rural residential buildings (Qi, 2010, cited in Shui/Li, 2012, 16). [2]

Unit	Building area billion m²	Energy consumption 10000 tce (tonnes of standard coal equivalents)	Energy consumption tce/m²
Energy consumption for heating in Northern urban buildings	10.2	16646	0.016
Energy consumption of urban residential buildings (except heating in the north)	15.1	15350	0.010
Energy consumption for public buildings (except heating in the north)	8	17056	0.021
Energy consumption for rural residential buildings	23.8	32357	0.014
Total / average	46.9	81409	0.017

Figure 10: Energy consumption in buildings per category in 2011
Source: [3]

Between 1996 and 2008, China´s residential urban energy consumption tripled and the energy consumption in rural buildings has increased significantly, though not as fast as urban consumption. The energy consumption of China´s residential sector is 326.1 GJ, 1.5 times higher than the energy consumption of the commercial sector. The substantial energy use in the residential sector of rural areas is generated from the combustion of biomass like straw and fuel or wood as well as waste. In 2008, most of the energy (47%) used in urban residential buildings is used for heating purposes, see Fig. 11. [4]

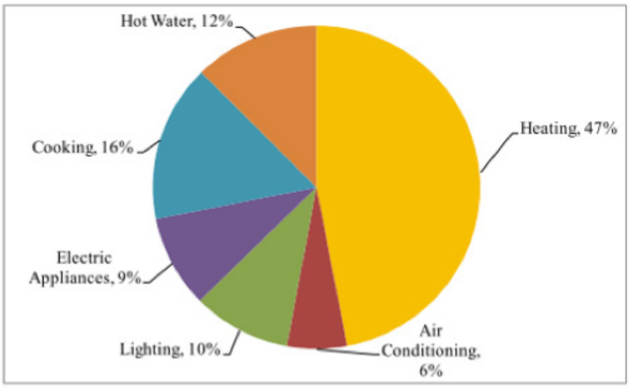


Figure 11: Energy use in urban residential buildings in China per purpose
Source: [6]

In the recent past, energy consumption for heating and cooling purposes increased strongly in the different zones (HSCW / HSWW / HSCW). Many new houses have currently been constructed and it is estimated that in 2030, 40% of the buildings would have been constructed after 2010. Therefore, it is now crucial to ensure that these buildings have high-energy standards in order to avoid a lock-in effect for many years to come. [5]

[1] Rommeney, 2008 in ibid.
[2] Qi, 2010, cited in Shui/Li, 2012, 16 ibid., 12.
[3] Ibid.
[4] Shui/Li, 2012 in ibid.
[5] Liu/Meyer/Hogan, 2010 in ibid., 9.
[6] BEERC, 2011 cited in Shui/Li, 2011 in ibid., 12.

4.2. CURRENT STATUS OF THE BUILDING STOCK

EU & GERMANY

As mentioned in Chapter 3.01, Europe is almost half the size of China. Regarding to that, we start with a short general picture of the European building stock characteristics, with an in-depth look into the ones in German.

The EU has a total building stock of 25 billion m^2, increasing at 1.2% per year. About 40% of the existing buildings were built before 1960s, generally with poor energy performance level, as no mandatory energy-efficiency codes existed in former times. [1] Due to the fact that there is a very low growth rate, the political main subject is about improving, upgrading as well as retrofitting the old building stock rather than focused on the efficiency and future. There is an estimated annual renovation rate of 1.2% of the existing building stock. [2]

In the European residential building stock, the standard household is about 2.4 persons, with an average area between 20 m^2 to 50 m^2 per person, depending if it is a multi-family home or single-family apartment, which are more common in Southern Europe. [3]

Similar to China, Europe with its size has several considerable climate zones, mentioned in detail in Chapter 3.2. As an overview, 4% of the population lives in the very cold Nordic/Baltic countries, 57% in the moderately cold climate zone and 39% in the warm Mediterranean areas. Over the whole Europe, buildings account for over 40% of the final energy, whereof the housing sector counts for 27%, almost three quarters of the total energy consumption. [4]

GERMANY

Germany, as the densest most populated country in Europe, is situated in the CW moderately cold climate zone. The actual status of the building stock is illustrated as follows:

In Germany, the biggest share of the building stock of 2.8 billion m^2 are mainly made up by residential buildings at 18.2 million - 15.1 million single or two-family buildings and 3.1 million several-family-buildings in comparison to 1.8 million non-residential buildings [5].

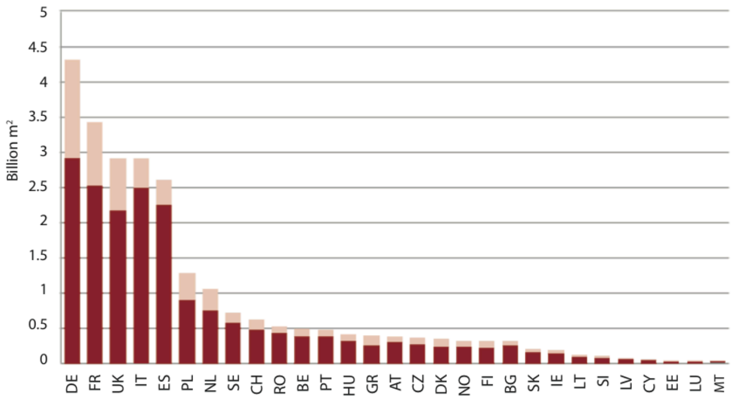


Figure 12: Floor space distribution per country
Source: [6]

[1] Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 46.
[2] BPIE, 2011 in ibid.
[3] Ibid.
[4] Joint Reserach Centre, 2011 in ibid.
[5] DENA, 2012 in Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study -," 13.
[6] Economidou et al., "Europe's Buildings under the Microscope," 29.
[7] BPIE survey, in ibid., 27.

In short, non-residential buildings has a relatively smaller share of the buildings stock and together with single and two family-houses, they have the biggest share of final energy consumption of 41%. Most of the 65% of the final energy consumption of 2010 was used in residential buildings with an 85% usage for heating purposes. [1] This specific energy consumption is also validated by a study of Shell/BDH in 2013, which estimates the energy for heating and warming water purposes, after declining from previous years, is still the major consumption between 2009 and 2011. Fig. 13. [2]

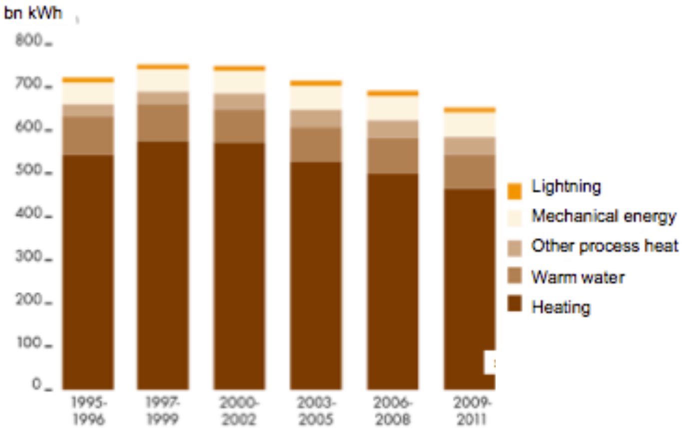


Figure 13: Development of final energy use in residential buildings per purpose
Source: [3]

Due to the long-lived building stock and declining population, the energy efficiency of existing buildings is of central importance in Germany. Furthermore, Germany´s slower growth in combination with an older building stock elevates the importance of retrofitting compared to China [4]. The residential building stock is the main share in Germany, totaling to 18.2 million buildings with the dominant amount of 15.1 million single or two-family buildings and 3.1 million several-family-buildings [5]. According to studies from 2011, until 1979, 75% of built structure in Germany´s overall building stock were from the times of the economic miracle. Only 6% of the building stock has been built between 2002 and 2009, so there is no denying that retrofitting is of an urgent importance Tremendous efforts have been made after Germany´s reunification in upgrading Eastern Germany´s buildings made of prefabricated slabs. In general, buildings in Germany are renovated every 30 - 40 years [6]. Approximately 2.1 billion m^2 apartments of these structures have been renovated since 2011, either fully or partially [7].

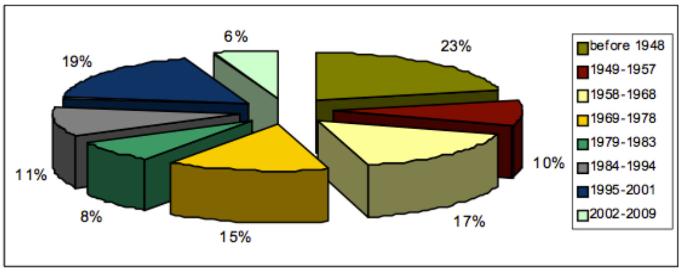


Figure 14: Development of final energy use in residential buildings per purpose
Source: [8]

[1] DENA, 2012, 14 in Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study -," 13.
[2] Ibid.
[3] Ibid.
[4] Amecke et al., "Buildings Energy Efficiency in China, Germany, and the United States," 4.
[5] Peter Tichauer, "Energieeffizienz in China. Ein Dena-Special in Zusammenarbeit Mit ChinaContact" (Deutsche Energie-Agentur GmbH (dena), April 2014).
[6] Ibid.
[7] GIZ, 2011 in: Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study -," 13.
[8] Ibid., 14.

PRELIMINARY REPORT

Regarding the current building stock, the situations in Germany and China are quite different, which needs to be reflected in respective policies, especially the several climate zones of China. The energy consumption for heating purposes of Northern China´s residential buildings was more than two to three times that of countries in similar climatic regions in Western Europe. Furthermore, Germany´s share of buildings built before 1979 constitutes 75% of the overall building stock while China has both a strong growth rate of new buildings and a large existing stock. Retrofitting policies are therefore essential. Hence, the focus in China has to be on policies for both new and existing buildings, whereas in Germany, the focus must definitely be on retrofitting existing building stock. [1]

Due to the similarity of China´s and Germany´s building types in case of prefabricated slabs, China might have a special interest in the German experience of retrofitting these structures. This knowledge transfer already took place within the framework of a GIZ project in 2007 [2].

[1] Ibid.
[2] Wollschläger, 2007a in: Ibid.

5. Methodology

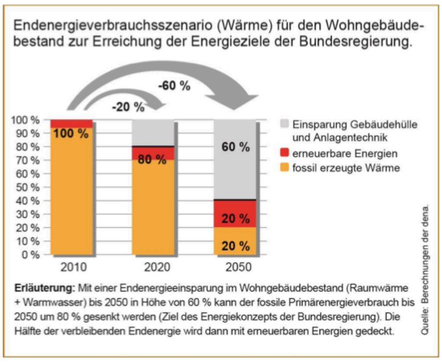
5.1. The potential and why EEI is & will become necessary

There is no recent review of the worldwide potential for energy efficiency improvement (EEI), but analysts claimed that as much as 29% of global baseline buildings´ CO_2 emissions in 2020 could be eliminated with investments that pay for themselves through reduced energy costs [1]. The largest part of this CO_2 emission reduction is associated with installation of energy efficient technologies. At the same time, the building sector – dependent on decisions by consumers and homeowners – face a large variety of market barriers that cause very substantial underinvestment in energy efficiency [2].

POTENTIALS - CHINA

There is a great potential of EEI [3] due to the rapid city growth - in 2000, there is 2 billion m^2 of new built buildings and a potential 42 billion m^2 of existing buildings with mostly bad energy performance. Assuming that all the new buildings implemented the actual energy efficiency standards and that existing building gets renovated step by step, there will be 420 billion KWh of electricity, 0.26 billion ton of standard coal and 0.846 billion ton of CO_2 saved each year till 2020 [4]. On the other hand, the development of the urban restructuring, starting in the late 90s, releases great potentials of EEI implementations, although it did not take place in an effective way yet. The city centres of great metropolis are getting restructured from the former role as an administrative, cultural and shopping centre with big residential parts making up to 70%, like in Shanghai [5], into international economic, financial and commercial centres.

POTENTIALS - GERMANY



In contrast to China, Germany is working towards the target to exit from nuclear and fossil-fuel energy, in order to fulfill the EU-goals of energy reduction illustrated in detail in Chapter 7. Almost 40% of the total energy consumed by buildings were a majority over 35-year-old and is therefore not aligned with the actual EU energy standards. A doubling of the renovation rate to about 2% would be a great effort for the domestic economy and would trigger billions of investment [6]. The annual energy savings, for example, range from 94 TWh[7] to 283 until 2020. In 2050, the corresponding annual energy consumption is expected at 2795 TWh [8].

Figure 15: Energy consumption zenario // Source: DENA[1]

[1] Mark Levine et al., "Residential and Commercial Buildings. In Climate Change 2007.pdf" (Residential and Commercial Buildings, 2007).
[2] Levine et al., "BUILDING ENERGY EFFICIENCY: BEST PRACTICE POLICIES AND POLICY PACKAGES," 3.
[3] Yong Liu, Xiangzhao Fu, and Qing Luo, "Discussion of Problems in the Development of Building Energy Efficiency in China," Vol. VI-10-3 (Building Commissioning for Energy Efficiency and Comfort, 2006), 1.
[4] Levine et al., "Residential and Commercial Buildings. In Climate Change 2007.pdf."
[5] Lin Chai, "Strategien Der Stadterneuerung in China" (Technical University of Berlin, 2011), 53.
[6] Ibid.
[7] TWh equivalent to 10^{12} terawatt hour

[8] Economidou et al., "Europe's Buildings under the Microscope," 15.

5.2. Methodology of evaluation

In order to meet these ambitious energy efficiency targets as mentioned as future goals above, it is necessary to set long-term policy commitments. Furthermore, in the building sector, policies are not effective over two or three years, but over two or three decades. This illustrates the importance of why it is necessary to set up a well-elaborated policy model. Incorporating energy-related requirements during the design or retrofitting phase of a building is a key driver for implementing energy efficiency measures, which in turn highlights the role of building energy codes in reducing CO_2 emissions and reaching the energy saving potential of buildings. [2]

This report will deliver an overview of the key driving policy factors, which have the main influence and impact of energy efficiency development. In the main body of this research, the following parameters get evaluated for each country by collecting existing data related to buildings and building policies:

- Building Codes
- Control, Inspection and Monitoring tools
- Building Energy labelling systems
- Private and Governmental Incentive structures

The data has been used to provide a fresh and up-to-date picture of where we stand in terms of the energy performance of our existing building stock and to form the basis of what is the future´s challenges and barriers, and which possible scenarios of the development of our buildings may take place. Considering the following points in order to provide a prediction of how a "best practice" scenario could work out as well as to evaluate which policies are working out or not:

- Building age
- Building area/size
- Typology
- Ownership profile
- Building location

It should also be noted that Norway and Switzerland has been also taken into account for Europe in general, and when it comes to energy consumption, the consumption during construction phase is not addressed within this paper.

[1] Dr. Philipp Prein, "14-06-02_Pressegespraech_EU-EnEffRicht_Hintergrundpapier.pdf" (DENA Deutsche Energie-Agentur, April 6, 2014).
[2] Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 98.

5.3. Analysis of the main building consumers

It is important for building energy conservation and emission reduction achievement to identify the major determinants of building energy consumption and related CO_2 emissions, and to get an overall understanding of the impacts of the identified determinants on energy consumption and emissions. Besides the economic and physical factors, there are various factors influencing building energy consumption and emissions simultaneously. For example, occupants' behaviours and activities, indoor environmental quality requirement, building characteristics (e.g. building material, structure, location, orientation, etc.), building services (e.g. heating, cooling, hot water supplying, etc.), climate (outdoor air temperature, solar radiation, wind velocity, etc.) and social factors like degree of education, etc. These factors should only be regarded here, in the following we will focus on the main building energy consumers.

It should be noted again, that energy-related behaviours in commercial buildings are different from those in residential buildings [1].

5.3.1. Building envelope

Particularly the building envelope (insulation) is of great importance, since other energy efficiency measures such as those for heating and cooling are highly dependent on the state of the building envelope [2].

In developed countries, approximately 20–40% of total energy consumption is a result of building heating and cooling operations, given that the demand of heating and cooling is largely due to heat transmission that occurs through the building envelope assembly, e.g. walls, roof, fenestration as well as doors etc. Hence, the thermal resistance of building envelope materials plays a vital role in the energy performance of buildings. [3]

5.3.2. Building equipment (HVACR)

Water heating, appliances, electronics, and lighting together contributes a great share of energy consumption of a building, but the largest part among building services is the growth in HVACR on cooling and heating systems and the energy use is particularly significant (50% of building consumption). [4]

[1] Lin and Liu, “CO2 Emissions of China’s Commercial and Residential Buildings,” 425.
[2] Greenovation Hub and Germanwatch, “Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study - ,” 10.
[3] Benjamin Park, Wil V. Srubar, and Moncef Krarti, “Energy Performance Analysis of Variable Thermal Resistance Envelopes in Residential Buildings,” *Energy and Buildings* 103 (September 2015): 317, doi:10.1016/j.enbuild.2015.06.061.
[4] L. Pérez-Lombard in Park, Srubar, and Krarti, “Energy Performance Analysis of Variable Thermal Resistance Envelopes in Residential Buildings.”

5.3.3. Building operations and behaviour

The way buildings are used has a substantial impact on the building energy consumption - choices of temperature setting, frequency of appliance use, and the amount and type of ventilation can lead to very different energy usage in similar buildings with similar equipment. Particularly in larger buildings, automated controls on lighting and HVACR can deliver large savings [1].

Hence, it is hard to estimate the share of energy due to operations, which is difficult to isolate[2] and which is therefore not addressed within this work.

[1] Amecke et al., "Buildings Energy Efficiency in China, Germany, and the United States," 06.
[2] Levine et al., "Residential and Commercial Buildings. In Climate Change 2007.pdf."

6. BUILDING ENERGY EFFICIENCY POLICIES IN CHINA

China is almost double the size of the European Union, which stretches over five climate zones and consists of 22 provinces, with a wide range of temperature and humidity levels, as mentioned above in Chapter 3. In respect to these facts and its huge aged- and fast growing building stock, there are different requirements to the policies for construction and retrofitting of buildings, as well as to the implementation to national and local administrative level.

China is ruled by a centralized government with its Ministry of Housing and Urban-Rural Development (MOHURD), known as Ministry of Construction before 2008, which is China´s regulatory agency for building energy code development and implementation.

In order to attain a successful development and implementation of building codes, MOHURD works with building science research institutes and universities on code development and revision, as well as with counterparts in provincial and local governments (see Fig. 16).[1]

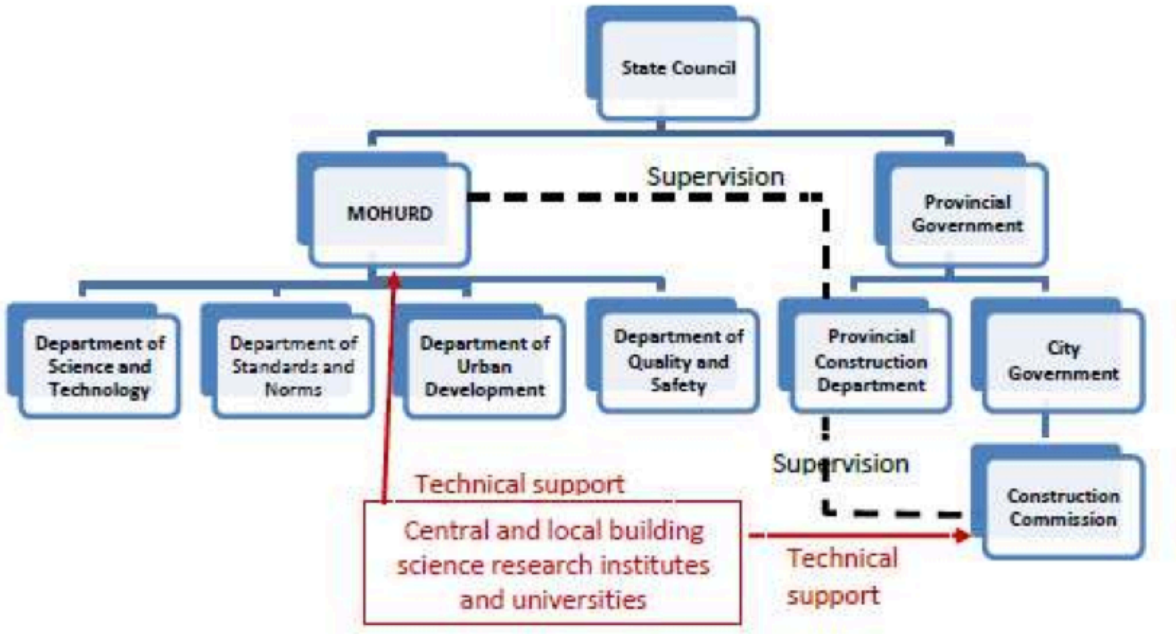


Figure 16: Government Organization Chart for Building Energy-Efficiency Policy Development and Implementation
Source: [2]

[1] Mark Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 98, http://escholarship.org/uc/item/5206n1xr.pdf.
[2] Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 98.

6.1. CHINA´S OVERALL ENERGY OBJECTIVES AND DIRECITVES

China has set a national goal to reduce its carbon intensity by 40-45% by 2020 in comparison to 2005. As a step towards this, the 12th Five Year Plan (FYP) has included the medium-term goal to reduce carbon intensity by 17% by 2015, in comparison to 2010[1]. This has constituted one of the central principles in China's economic and social development, and has been applied by various ministries, including MOHURD. [2]

In 2003, it was decided that new residential buildings in the HSWW zone needed to have an EEI of 50% in comparison to buildings of the 1980s [3]. Since 2010, new buildings in the Severe Cold and Cold zones, as well as Hot Summer and Cold Winter zone (HSCW) need to have an EEI improvement of 65%, again compared to buildings of the 1980s. [4]

Due to China's national conditions, Chinese policies on building Energy Efficiency (EE) focus mainly on civil buildings, including both residential and public buildings (government offices, commercial buildings, schools, and hospitals) [5]. There is a broad range of codes and regulations addressing EEI in buildings, illustrated in the following, with China being one of the first developing countries to set up binding codes on EEI for new buildings in 1980.[6]

Owing to the five different climate zones, the Chinese government has developed respective building codes corresponding to each region, beginning in the 1980s [7].

It is remarkable, that in 2005, a national design standard for commercial buildings in all climate zones was adopted and implemented, similar to the EU-approach displayed in Chapter 7. Both the residential and commercial building design standards cover only building envelopes and heating, ventilation, and air conditioning (HVAC) systems. China has a separate standard for lighting design in buildings, which was adopted in 2004.

Next to these codes and standards, there are a series of private and governmental incentives, as well as two voluntary labelling systems mentioned in the following Chapter 5.3 & 5.4.

In addition, the central government is also supporting the construction of green eco-cities and eco-districts with total funding allocation of RMB 50 million (USD $8 million). These actions are intended to help China meet its targets of constructing one billion m^2 of additional green buildings by 2015, and a green building share of 30% of total new construction by 2020. [8]

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1 "Center for Climate and Energy Solutions," *C2ES*, September 4, 2015, http://www.c2es.org/international/key-country-policies/china/energy-climate-goals-%20twelfth-five-year-plan.
2 Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study - ," 15.
3 Shui and Li, "Building EE Policies in China, Global Uilding Performance Network," 35.
4 Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study - ," 09.
5 Shui and Li, "Building EE Policies in China, Global Uilding Performance Network," 16.
6 Levine et al., "BUILDING ENERGY EFFICIENCY: BEST PRACTICE POLICIES AND POLICY PACKAGES."
7 Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study - ," 15.
8 Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 124.

6.2. IMPLEMENTATION OF THE DIRECTIVES INTO THE NATIONAL ENERGY CODES

China has three residential building energy efficiency design standards, which cover four out of the five climate zones. The standards reflect the initial iterative process of Chinese building code development, which contrasts with the later centralized national code for commercial buildings. All three-design standards apply to new residential construction, residential building expansion or additions, and residential building retrofit projects. The basic metric for thermal integrity in all three-design standards is a reduction target for heating energy consumption relative to a baseline. Although the three residential building codes are similar in having heating energy intensity reduction targets, other features of the codes differ as a result of specific climate zone characteristics. [1]

6.2.1. BUILDING CODES

HEATING ZONES

The Energy Conservation Design Standard for Residential Buildings in Heating Zones (JGJ 26-95) is China´s first energy efficiency standard for residential buildings, issued in 1986. The target here was to reach a 30% reduction of the heating energy consumption that is relative to the heating energy consumption of typical inefficient buildings designed from 1980 to 1981, the so-called baseline residential buildings. [2] In December 1995, the reduction target was raised to 50% of heating energy consumption. The latest revision took place in August 2010 where the reduction target was adjusted and fixed at 65%. [3] Building heat loss and coal consumption indices are provided in the design standard. These indices can be considered by the designers; and the use of a steady-state method for calculating heat loss for buildings, that differs from the illustrative buildings, represented in the indices. [4] Furthermore, the standard contains sections on thermally efficient building and heating design and provides information for the total installation capacity of the heat source with building heating load, as well as information on hydraulic balancing devices and piping and heating system insulation. [5]

HOT SUMMER AND COLD WINTER ZONE

In 2001, China's design standard for residential buildings in the hot summer and cold winter climate zone (JGJ 134-2001) was approved. Similar to the residential building design standard of the heating zones, this residential building standard for the hot summer and cold winter zone provides specifications on indoor thermal environment requirements

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[1] Ibid., 98.
[2] Lang, 2004 in: Ibid.
[3] Long, 2011 in: Ibid.
[4] Lang, 2004 in: Ibid.
[5] Bin Shui, Meredydd Evans, and Sriram Somasundaram, *Country Report on Building Energy Codes in China* (Pacific Northwest National Laboratory, 2009), 11, http://asiapacificpartnership.org/pdf/BATF/country_report/PNNL_(2009)_Country_Report___India.pdf.

as well as information on energy efficient building design and HVAC systems. Two approaches are offered by this standard to ascertain whether a proposed building design will reach the required 50% reduction in heating and air conditioning energy consumption, in relation to a reference building with the same indoor thermal conditions. [1] The first dispositive approach enables the design to conform to the maximum allowable heat-transfer coefficient (U-value) for building envelopes and a minimum required energy efficiency ratio (EER) for heating and air-conditioning equipment [2]. More flexibility is provided by the performance based second approach that sets a maximum permissible heating and cooling energy consumption per m^2, which refers to the heating and cooling degree-days of the project site. Hence, dynamic simulation software's like DOE-2 can be used by designers to calculate the building´s energy consumption under non-steady-state heat transfer conditions. [3] In 2010, this design standard from 2001 got adapted to introduce a new shading coefficient requirement, a more stringent requirement for envelope thermal performance, as well as technology measures [4].

HOT SUMMER AND WARM WINTER ZONE

The latest residential building energy-efficiency design standard for the hot summer and warm winter zone (JGJ 75-2003) was implemented in 2003 with a 50% reduction of the annual heating and air-conditioning energy consumption. Similar to the residential building standard of the hot summer and cold winter zone, a dispositive, as well as a performance-based approach is included [5]. Under the dispositive approach, glazing requirements and shading coefficients to address solar radiation passing through windows, as well as heat-transfer coefficients for lightweight walls and roofs, are the main climate-related regulations [6], whereas the maximum allowable heating and cooling energy intensity is performance based on simulated results for a reference building [7]. Currently, this standard is under review for a further revision [8].

RENOVATION OF EXISTING HEATED RESIDENTIAL BUILDINGS

China´s technical standard for energy efficiency retrofits (JGJ 129-2000) of existing residential buildings that have central heating systems and are located in cold and severe cold climate zones was implemented by MOHURD in 2001. In 2000, many existing buildings did not meet the design standard for residential buildings in the heating zone (JGJ 26-95). The energy efficiency retrofit standard JGJ 129-2000 specified the conditions under which existing structures should be retrofitted and it the scope of the retrofit. [9] According to this standard, all existing residential buildings need to be retrofitted if (1) the building cannot meet the design standard, or (2) the existing boiler

[1] Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 99.
[2] Lang, 2004 in: Ibid.
[3] Shui, Evans, and Somasundaram, *Country Report on Building Energy Codes in China*, 13.
[4] Long, 2011 in: Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 99.
[5] Lang, 2004 in: Ibid.
[6] Ibid.
[7] Shui, Evans, and Somasundaram, *Country Report on Building Energy Codes in China*, 15.
[8] Yu, 2011 in: Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 99.
[9] Ibid., 100.

system has an efficiency of less than 0.68 or the outdoor pipe network transmission efficiency is lower than 0.90, and (3) the building is either a hotel, guest house, childcare facility, or another kind of residential building that is centrally heated, and which cannot meet the local insulation requirements for building envelopes [1]. In the cold and the severely cold climate zone, this standard also addresses retrofits of building envelopes and of heating systems, other than central heating [2].

CHINA'S DESIGN STANDARDS FOR COMMERCIAL BUILDINGS

The national design standard for China´s energy efficient commercial buildings (JGJ 189-2005) was issued in 2005. This standard covers new construction as well as expansions and retrofits with a 50% reduction of lighting and HVAC energy consumption, in relation to the energy use in buildings constructed in the early 1980s. The benchmark values for lighting and HVAC energy use are set by DOE-2 software. Furthermore, two main sections that specifies the minimum insulation requirements for building envelopes in different climate zones, as well as recommended HVAC systems, are included in this standard. These sections provide guidelines rather than simply listing efficiency specifications. For reaching the lighting and HVAC requirements, only a dispositive approach is offered, whereas a performance-based trade-off approach can be used for building envelope requirements, if dispositive requirements are not met. [3]

LIGHTING DESIGN STANDARDS

In 2004, China's national standard for lighting design in residential, commercial, and industrial buildings was issued. The lighting power density is used as the key indicator for lighting energy efficiency. Compulsory maximum and future target values for commercial and industrial buildings, as well as voluntary values for residential buildings are set by this standard. [4]

[1] MOHURD, 2000 in: Ibid.
[2] Ibid.
[3] Ibid.
[4] Shui, Evans, and Somasundaram, *Country Report on Building Energy Codes in China*, 18.

6.2.2. INSPECTION AND MONITORING

CODE COMPLIANCE ENFORCEMENT AND MONITORING IN CHINA

Building control requirements prior to, during and upon completion of the construction phase require announcement to authority, application for permits, approval of plans, inspections by authority and completion of certificates [1]. The annual national inspection conducted by MOHURD and its supervision is a critical component in the enforcement of China´s building energy codes. Provisions on the Administration of Energy Conservation for Civil Buildings (1999), Notice on the Strict Implementation of Energy Efficiency Design Standards for New Residential Buildings (2005) issued by MOHURD, Energy Conservation Law 2007 revision and Regulations on Energy Conservation in Civil Buildings (2008) are in accordance with the regulatory support for building energy efficiency inspection and monitoring. [2]

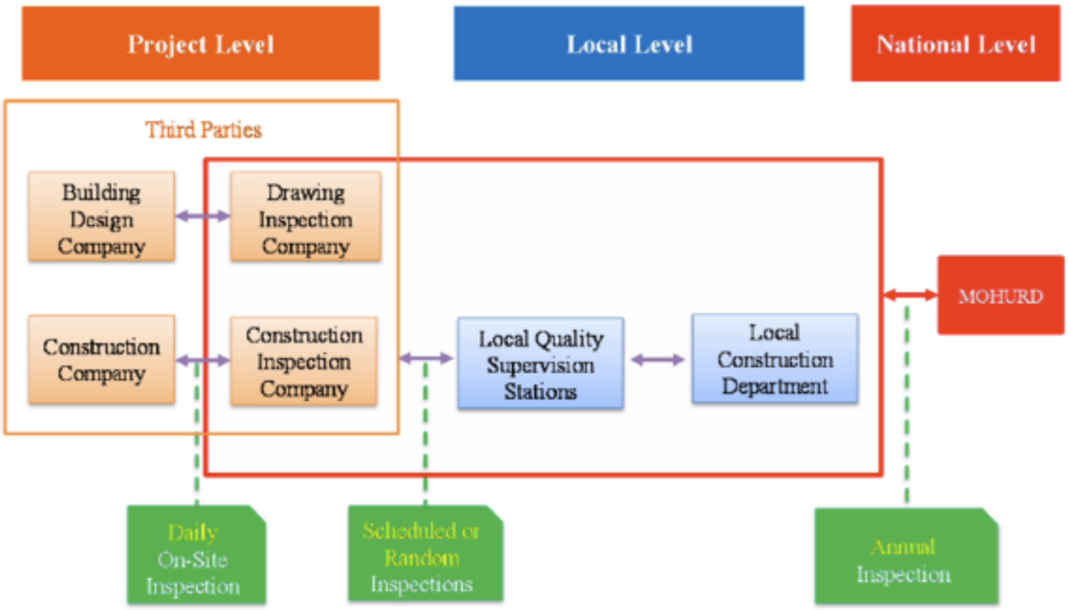

Figure 17: Three-Level Inspection System
Source: Ministry of Housing and Urban-Rural Development [3]

It is a requirement for any new residential community of at least 50,000 m^2 project size to undergo the construction inspection. For smaller residential projects, the local MOHURD will determine at the provincial and municipal level if construction inspection will be required. If the construction project relates to the public and commercial sector with a total investment over RMB 30 million, there needs to be construction inspection as well as for any schools, cinemas and stadium buildings, and buildings supported by foreign aid and loans. The annual nationwide inspection of building energy efficiency and emissions mitigation, that is conducted by MOHURD since 2005, evaluates the level of compliance

[1] Economidou et al., “Europe’s Buildings under the Microscope,” 89.
[2] Jun Li and Bin Shui, “A Comprehensive Analysis of Building Energy Efficiency Policies in China: Status Quo and Development Perspective,” *Journal of Cleaner Production* 90 (March 2015): 330, doi:10.1016/j.jclepro.2014.11.061.
[3] Shui and Li, “Building EE Policies in China, Global Uilding Performance Network,” 5.

with building energy codes in various cities. Each team of the approximately ten team members from MOHURD consists of MOHURD´s officials, experts on building energy codes from various research institutes, local code management and enforcement officials that cover the majority of 31 provincials (22 provinces, 4 municipalities and 5 autonomous regions). The capital city of each provincial division is selected by default for annual inspection. A randomly selection is done in each provincial territory: for two cities or districts for municipalities. [1]

IMPLEMENTATION FOR NEW CONSTRUCTION (LOOP SYSTEM)

For new constructions, the regular inspections follow a "loop system" of four separate phases of administrative review and licensing. (1) In the first phase - after the land use has been approved by the local planning authority, the developer has to open a bidding process to evaluate certified and registered third party building design companies, construction companies and construction inspection companies. The Planning Bureau and the Construction Commission will work together to investigate whether the main façade, layout and shape of the design meet the energy efficiency requirements. (2) Based on the initial review of the building design, the local construction department gives permission for the building project to proceed. (3) The project´s blueprints and engineering plans get evaluated and approved by the local construction department to ensure compliance with mandatory energy standards. The construction permit will be issued by the local construction development. If permits are not issued, construction works must not begin. The building design and construction enterprises, and respective supervisory units, assume responsibility for obtaining energy labelling certification, verification of construction completion and insulation quality assurance. To assure compliance with energy efficiency standards throughout the construction process, inspections by construction supervision companies, testing labs and quality control testing stations are carried out on site. (4) As soon as the construction is completed, the developer submits a completion report based on the third party´s inspection results to overhaul an occupancy permit. Since 2007, specific details and a checklist of items are provided by MORHUD´s Code of Acceptance. [2]

If the work of a construction company does not comply with building energy codes, the identified corrections by the inspection company have to be corrected and a penalty of 2 - 4% of the contract costs has to be paid, or otherwise the developer as well as the relevant government bodies will be informed. Furthermore, the construction company will not be allowed to proceed to the next phase of the construction procedure without the construction inspectors´ signature of approval. [3]

[1] MOHURD, 2001 in: Li and Shui, "A Comprehensive Analysis of Building Energy Efficiency Policies in China," 330.
[2] Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 101–102.
[3] MOHURD, 2008 in: Li and Shui, "A Comprehensive Analysis of Building Energy Efficiency Policies in China," 331.

6.2.3. CHALLENGES AND BARRIERS OF IMPLEMENTATION

IMPLEMENTATION OF THE HEATING REFORM

The heat reform has been undertaken since the 1990s, initiated by MOHURD to fix one major problem regarding heating systems. The cost of residential heating in the cities and towns of the northern heating area were subsidized by the government. The heat expenses were calculated by heating area rather than actual heat consumption, which as a result did not cause any motivation towards an energy efficient behaviour of the inhabitants or improvement of the existing buildings. A considerable amount of energy got therefore wasted. [1] Less than half of the new buildings in northern regions had meters installed, but more than half of them did not use any consumption based billing systems in the time from 2008 to 2010. [2] Consequently, the aim of the heat reform is to renew the heating pricing system and to establish market mechanisms that will encourage the heat suppliers to improve the energy efficiency of their heat supply networks. [3]. Despite an increasing number of renovation and retrofit initiatives, China´s delayed heat reform has a negative impact on the cost-effectiveness of building energy efficiency investments of the economically less developed northern heating zone. The energy price subsidies have therefore created a counterproductive impact on China´s incentives for building high efficiency architecture. (Li and Shui, 2015, pp. 340–341)

DIVERSE OWNERSHIP STRUCTURE OF HOUSING

Since the agreement of all owners is necessary, diverse ownership structures can make retrofitting measures difficult, like installing the insulation of walls and ceilings that have to be conducted for the whole building rather than for just single apartments. Furthermore, some companies still own buildings after the housing reform, while the residents own only the apartments [4]. The so-called "investor-user dilemma" occurs when investors, who are the ones to invest in the energy efficiency of the building but are not actually living in the building, do not receive the benefits of the energy savings. Therefore, the motivation to invest in an energy efficient retrofitting remains low, which becomes especially relevant if the building is sold after its construction. [5]

ADMINISTRATIVE BARRIERS

It is difficult to enforce China´s legal building codes due to the lacking penalties in case of non-fulfillment [6]. As a result, half of the newly built (then) buildings in 2006 did not implement the mandatory energy standards during construction [7].

[1] Ibid., 339.
[2] Shui and Li, "Building EE Policies in China, Global Uilding Performance Network," 73.
[3] Li and Shui, "A Comprehensive Analysis of Building Energy Efficiency Policies in China," 339.
[4] GIZ, 2010 in: Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study -," 17.
[5] Oberheitmann, 2012 in: Ibid.
[6] Richerzhagen, *Energy Efficiency in Buildings in China*.
[7] Qiu, 2007 in: Yurong Zhang and Yuanfeng Wang, "Barriers' and Policies' Analysis of China's Building Energy Efficiency," *Energy Policy* 62 (November 2013): 771, doi:10.1016/j.enpol.2013.06.128.

MARKET BARRIERS

The Chinese market for energy-saving evaluation companies is still weak, especially for the heating and cooling systems, which is partly caused by the administrative lack of penalties and by the missing financial incentives by the state [1]. In Beijing, for example, only six enterprises had the qualification to evaluate heating energy savings in 2010 [2].

6.3. BUILDING ENERGY LABELLING

Whole-building energy labelling is comparatively new in China, although energy labelling, like applying energy information labels, has been an important energy efficiency policy tool. The Green Building Evaluation and Labelling program (GBEL) and the Building Energy Efficiency Evaluation Labelling program (BEEL) are China´s two domestic building energy-labelling programs, established by MOHURD in 2008. The international green building program and market-based Leadership in Energy and Environmental Design (LEED) is also available to Chinese project developers for participation. [3]

GREEN BUILDING PROGRAM GBEL

Facing challenges in terms of energy security and climate change mitigation at a global level, China has gradually altered the building energy efficiency policy portfolio to voluntary green building initiatives[4]. China is currently implementing voluntary appliance to the energy efficiency labelling scheme GBEL, established late 2007, and is similar to Energy Star in the USA which mandates labelling adaptation from EU for a few appliances [5].

A group of Chinese building experts was formed by MOHURD in 2011 to review the revised version of "Technical Guide for Labelling, Testing and Evaluating Civil Building Energy Performance" from 2007 - "The Energy Performance Certification Standards of Building". The five-star scale from the building energy standards from 2007 was changed to a three-star scale of the version in 2011. The six building energy efficiency indexes of China´s green building evaluation system GBEL are (1) land use and outdoor environment, (2) energy efficiency and utilization, (3) water efficiency and utilization, (4) materials saving utilization, (5) indoor environment quality and (6) operation management for residential buildings or comprehensive performance of the building´s life cycle for public buildings. [6] The buildings need to reach a certain number of criteria to

[1] Kang and Li, 2006 in: Sha Yu, Meredydd Evans, and Qing Shi, *Analysis of the Chinese Market for Building Energy Efficiency* (Pacific Northwest National Laboratory, 2014), http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22761.pdf.
[2] Beijing Times, 2010 in: Zhang and Wang, "Barriers' and Policies' Analysis of China's Building Energy Efficiency," 771.
[3] Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 106.
[4] Li and Shui, "A Comprehensive Analysis of Building Energy Efficiency Policies in China," 326.
[5] Amecke et al., "Buildings Energy Efficiency in China, Germany, and the United States," 11.
[6] Li and Shui, "A Comprehensive Analysis of Building Energy Efficiency Policies in China," 334.

attain one, two or three stars of the green building labelling system[1]. The certification can be either issued for the design of the building with a validation for one year or, after an evaluation of the actual energy demand of the building with its actual energy savings, for three years [2] A one-star rating indicates that this building is between 0 and 15% more energy efficient, relative to a reference building as described in the current design standards for Building Energy Efficiency (BEE). A two-star rating indicates an increase between 15% and 30% and a three-star rating indicates more than 30% increment. [3] Local government agencies certifies one and two-star buildings, while the central government agencies are in charge of the three-star certifications [4].

The LEED green building rating system, which certifies and rates projects as silver, gold or platinum, is also used in China. The LEED evaluation criteria are similar to the categories in China´s three-star GBEL. [5]

BUILDING ENERGY-EFFICIENCY LABEL BEEL

Efforts have also been made to increase in accordance with energy standards to regulate building envelopes and HVAC systems in new structures. The BEEL program is a one-to-five star rating system with focus on HVAC system efficiency, compliance to mandatory standards and optional building efficiency features. Two evaluation scores are included: (1) a theoretical evaluation based on energy simulations of the building design and (2) a measured evaluation based on operational energy consumption. [6] The BEEL´s theoretical rating score out of 100 points and a star rating for buildings have, similar to the GBEL program, a validation for one year. After an evaluation of the actual energy demand of the building with its actual energy savings, the measured rating score has a validation for five years. [7]

The Civil Buildings Energy Efficiency Regulation requires government-owned office buildings or commercial buildings of more than 20,000 m^2 to undertake energy performance rating and labelling [8], as well as to publish the evaluation results [9]. The Interim Management Regulation of Civil Buildings Energy Efficiency Performance Evaluation and Labelling was issued by MOHURD as a guiding policy document to regulate the implementation of the BEEL program; in addition, four specific guidelines are included to support the BEEL program. Furthermore, BEEL is mandatory for buildings that applies for the GBEL program [10]. The scope, specific rating criteria, as well

[1] Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study - ," 15.
[2] Shui and Li, "Building EE Policies in China, Global Uilding Performance Network," 46.
[3] Li and Shui, "A Comprehensive Analysis of Building Energy Efficiency Policies in China," 334–336.
[4] Schroeder, Guo, unpublished draft in: Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study -," 15.
[5] Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 106.
[6] Ibid.
[7] Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 116.
[8] State Council of China, 2008 in: Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 106.
[9] STDDC & CBEE of MOHURD, 2011 in: Ibid.
[10] Mo, Burt, Hao, Cheng, Burr, & Kemkar, 2010 in: Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 106.

as the methodology of both labelling programs do differ, even though a few similarities can be found within the goals and the design of these programs. [1]

CHALLENGES AND BARRIERS OF THE LABELLING SYSTEMS

Green Building labels still face a number of barriers and challenges, although there is a rapid growth in the number of building projects certified under the GBEL program. China´s building codes have a long history and the government has shown greater attention in implementing more tools in the recent years. But some challenges and barriers to actualize energy efficiency building codes still remains[2]:

LEGAL BARRIERS

There are no compulsory nor incentive policies that supports labelling on a national level, although some provinces or cities have supporting polices in place. But the reach and market impact of the GBEL program is limited by the lack of uniformity in policies.

The market share and presence of GBEL buildings is still very small with an estimated share of approximately 0.5% of total new construction floor area in 2010 [3].

SOCIAL BARRIERS

The absence of national policies and uniformity of local policy support, and therefore the very small market share of GBEL buildings, are causing relatively low levels of awareness of the energy efficiency concept, as well as a scarce awareness of the benefits of green buildings among developers. As a result, there is no consumer demand for GBEL, so developers hardly feel any market pressure to participate in the GBEL program. The important determinants to slow or advance the successful implementation of building energy efficiency or labelling-systems are lifestyle, culture and behavior of consumers. There is no strong demand for high energy-efficient buildings, due to the fact that the majority of China´s people are used to the present life. Furthermore, most Chinese population assumes that it is the government who should play a key role in energy saving instead of linking the enhancement of energy efficiency to their own behaviour. [4]

STIMULATION BY THE GOVERMENT

Spreading information via media to provide knowledge on energy efficiency issues to the general public is of great importance in China. But due to the little attention on this topic by China´s opinion leaders today, the public acceptability and knowledge about energy efficiency remains low. [5]

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[1] Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 106.
[2] Ibid., 112–113.
[3] MOHURD, 2011 in: Ibid., 113.
[4] Zhang and Wang, "Barriers' and Policies' Analysis of China's Building Energy Efficiency," 772.
[5] Jing Liang et al., "An Investigation of the Existing Situation and Trends in Building Energy Efficiency Management in China," *Energy and Buildings* 39, no. 10 (October 2007): 1105–1106, doi:10.1016/j.enbuild.2006.12.002.

6.4. INCENTIVES

6.4.1. INCENTIVES FOR RESIDENTIAL BUILDINGS

As part of the on-going heating reform efforts, financial incentives for retrofitting heating systems in northern China´s residential buildings have been launched by the Ministry of Finance (MOF) and MORHURD. In late 2007, the Interim Administrative Method for Incentive Funds for Heating Metering and the Energy Efficiency Retrofit for Existing Residential Buildings (MOF No. 957) [1] has been implemented as an incentive policy to set the goal of retrofitting of 150 million m^2 of existing residential buildings in 15 provinces and municipalities from 2008 to 2010 [2].

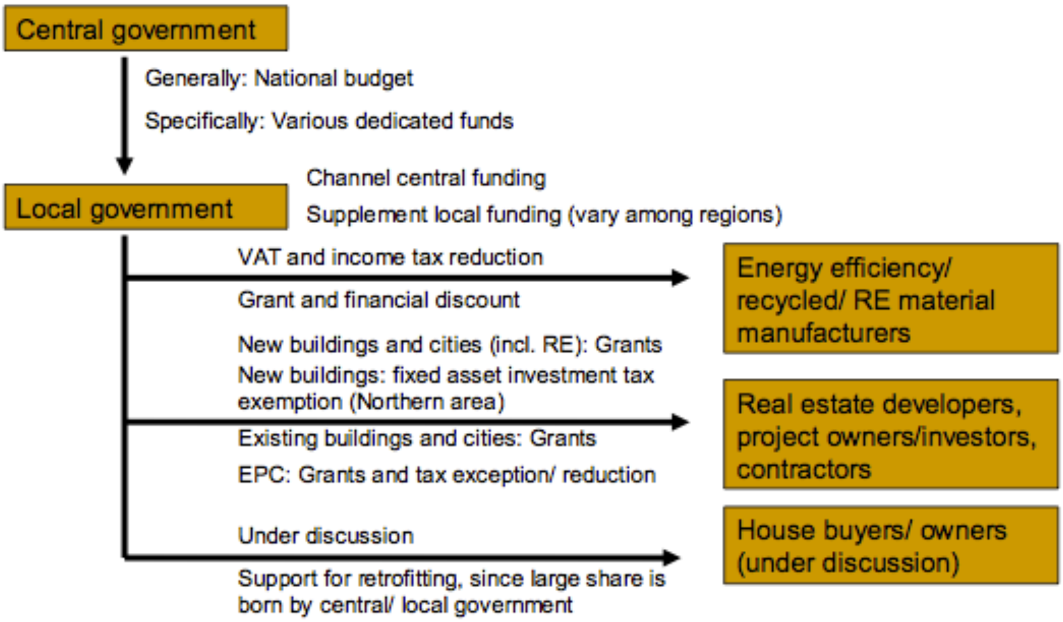

Figure 18: Financial flow from the central government for the financial support of EEI in buildings Source: [3]

Residential retrofit projects in the targeted regions must fit into at least one of the following three categories to qualify for the retrofit incentive program with respectively 10%, 30% and 60% of funding distributed to each task: (1) building insulation, (2) indoor heating system meter and temperature control device installation and/or (3) heat source and network pipeline retrofits. Provincial governments receive 10% of the incentive, whereas the remaining 90% is settled at the end of the year after actual energy savings have been measured. Due to the fact that many households only install a heat meter rather than carrying out the whole retrofit program including the envelope and heat supply network retrofits, despite being given comprehensive retrofit incentives, the savings per m^2 achieved from energy retrofits reflect only half of the target. [4]

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[1] MOF, 2007c in: Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 120.
[2] Zhong, Gai, Wu, & Ren, 2009 in: Ibid.
[3] Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study - ," 18.
[4] Levine et al., 2010 in: Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 120.

The following three incentives have been launched to support China´s energy efficiency in buildings:

ADMINISTRATIVE METHODS ON THE FINANCIAL SUBSIDY FUND FOR PROMOTING HIGH-EFFICIENCY LIGHTING PRODUCTS

In 2007, the regulation "Administrative Methods on the Financial Subsidy Fund for Promoting High-Efficiency Lighting Products" has been released by the National Development Reform Commission (NDRC). The intention of this subsidy fund was to maintain the substitution and replacement of 50 million incandescent lamps with high-efficiency lighting in 2008 and 2009 [1]. 30% of the cost of qualifying high-efficiency lighting products for bulk users, such as industrial enterprises, hospitals, schools, hotels, and airports, have been covered by the subsidy as well as 50% of the cost for individual users including urban and rural residents [2].

INTERIM MANAGEMENT METHODS ON FINANCIAL SUBSIDY FOR APPLICATION OF BUILDING-INTEGRATED SOLAR PHOTOVOLTAICS

MOF and MOHURD began promoting building-integrated renewable energy demonstration projects after the passage of China's Renewable Energy Law in 2005 by issuing management regulations for overseeing these projects in 2006. The specific encouragement of the application of PV and water heater technologies, ground-source heat pumps and water-source heat pumps followed in 2007. The very first Chinese solar subsidy program to support building integrated solar PV systems as well as rooftop systems was launched in 2009, with passage of the "Interim Management Methods on Financial Subsidy for Application of Building-Integrated Solar Photovoltaics". [3]

NOTICE OF FISCAL POLICY FOR ENERGY EFFICIENT AND EMISSION REDUCTIOM DEMONSTRATION PROVINCES AND CITIES

Under this notice, which was issued in 2011, financial incentives are provided to three cities (Bejing, Shenzhen and Chongqing) and five provinces (Jilin, Zhejiang, Jiangxi, Hunan and Guizhou) to support six different initiatives, which include green buildings and BEE as part of the 12th Five-Year-Plan´s energy and emissions reduction efforts [4].

The possibility to provide limited national subsidies to developers for using more efficient building materials and renewable technologies, like insulation and rooftop solar water heaters, have also been discussed by MOHURD officials. In the meantime, some provincial governments, like the government of Hunan province, have already started to subsidize factories that produce energy-efficient materials, such as triple-layer insulated glass and solar panel components[5].

[1] Zhou, McNeil, & Levine, 2010 in: Ibid., 123.
[2] REEEP, 2009 in: Ibid.
[3] MOF, 2009 in: Ibid.
[4] MOF, 2011b in: Mark Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 124, http://escholarship.org/uc/item/5206n1xr.pdf.
[5] Bradsher, 2011 in: Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 124.

6.4.2. PRIVATE FINANCING

GREEN CREDIT POLICY

China´s green development is mainly supported by the banking sector that provides over 80% of financing to enterprises in China[1]. The so-called "green credit", which was jointly released in 2007 by the Ministry of Environmental Protection (MEP), the People´s Bank of China (PBC) and the China Banking Regulatory Commission (CBRC), is one of the policy tools that encourages a green investment in the building sector. It also restrict banks from issuing loans to energy intensive and high polluting projects. The green credit policy is still at an early stage of development; it is supported by two additional documents containing guidelines and suggestions to help implement the green credit policy [2] which was published in 2012 and 2013 accordingly.

EXEMPLARY PRACTICES FROM BANKS

Next to the ambitions of Chinese banks like the Industrial Bank, which has developed a standard Energy Management Contract financing product to support solar hot water project design, construction and operation, international financial institutions are also actively engaged in triggering investment from China´s banks by providing concessional loans, introducing business models and by building capacity. The International Finance Corporation (IFC) has launched the "China Utility-Based Energy Efficiency Finance Program (CHUEE)" in 2006 to support Chinese banks´ lending to promote energy efficiency mainly in the sector of industry, municipal facilities and buildings as well as in the field of renewable energy. But due to the short-lived policy signals to support the private sector in implementing green credits, and the lack of established instruments to assess and control credit risk, most Chinese banks are still in a wait-and-see-position. In general, the insufficient information provided about the risks and the long-term benefits for the building industry leads to a remaining low number of participating banks with a reduced size of their financial investments. [3]

[1] Motoko, 2011 in: Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study -," 23.
[2] CBRC, 2012 and 2013 in: Ibid.
[3] Ibid., 23–24.

7. BUILDING ENERGY EFFICIENCY POLICIES IN GERMANY

The European Union stretches over many different climate zones too, with a broad range of thermal qualities and a wide array of building-types, as mentioned in Chapter 2. It is spread over 27 countries[1] with different ages and constantly expanding building stock. From styles of living, single-family dwellings or multi-family dwellings, to policies for the construction and refurbishment of buildings, there are significant differences between regions and countries. [2]

Compared to these facts, the main difference to China is that the European Union´s policy's intent is to unify the 27 member states with a collective mandate. This mandate is the first major attempt, requiring all member states to introduce a general framework for setting building energy code requirements, based on a "whole building" approach (so called performance-based approach) and is implemented by a EU institution called Energy Performance Buildings Directive (EPBD), coded as a national law in January 2006, illustrated in detail, in the following:

One of the most important points for a successful implementation of these EPBDs requires the design of interdependent instruments that are compatible with the everyday practice of the stakeholders, as well as the involvement to the structure of the local market. It is also necessary that the scheme is in-line with the specific characteristics of the building stock which at the same time includes an approach that should be embedded in the legislative and political structure that fits into the culture of each member state. [3]

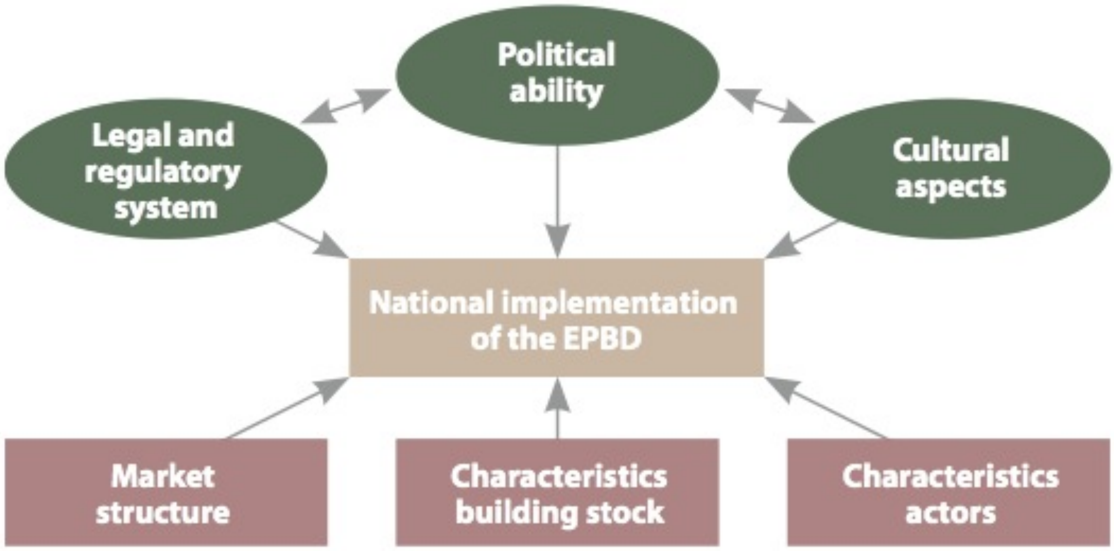

Figure 19: Influencing factors on national implementation of the EPBD
Source: [4]

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[1] Norway and Switzerland are included
[2] Economidou et al., "Europe's Buildings under the Microscope," 19–20.
[3] Constantinescu Tudor, "Energy Performance Certificates, from Design to Implementation" (The Buildings Performance Institute Europe (BPIE), 2010), 10.
[4] Ibid.

7.1. EU´s & GERMANY´s OVERALL ENERGY OBJECTIVES AND DIRECTIVES

The German Energy Concept (BMWi & BMU, 2010) specifies national efficiency long-term goals with mid-term goals, including a 80% primary energy demand reduction goal by 2050 for the building sector, ensuring that all new build buildings are climate neutral by 2020 and by increasing the thermal retrofit rate to 2%. [1]

The European Union has set its energy savings target of 20% by 2020, mainly through energy efficiency measures. The EU has also committed to reduce about 80-95% Green House Gas Emissions (GHG) as part of its road map to a low-carbon economy by 2050. At the moment, EU buildings consume almost 40% of the total final energy. [2]

At the European level, the main policy driver related to the energy use in buildings is the EPBD which was implemented in 2002, coded as a national law by 2006 and revisited every five years in order to monitor the goals and adjust the objectives.

Although subsidiarity applies to implementation of the EPBD, member states are required to introduce a methodology at a national or regional level in order to fulfill the EPBD objectives, certification, inspections, training or renovation, for the so-called National Energy Efficiency Action Plans. [3]

EPBD 2002, Three Key Elements:

- Setting minimum energy performance requirements for new construction and large existing buildings that undergo “major renovation” that has an area over 1.000 m^2 (Articles 4, 5 and 6)
- Certifying energy performance of buildings via energy performance certificates (EPCs) (Article 7)
- For heating, ventilation, and air-conditioning (HVAC) systems specifically, the directive requires either mandatory inspections of larger boilers, air-conditioning plants, and heating systems older than 15 years of age; or advice on the efficient use and replacement of these systems. (Articles 8 and 9)[4]

EPBD’s 2010, Revised Main Provisions:

- A comparative methodology framework to assess the "cost-optimal" level of standards. In January 2012, the Commission published a comparative methodology for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements over their economic life cycle (EC, 2012a). Each member must evaluate its efficiency requirements based upon optimal cost by June 30, 2012.

[1] Amecke et al., “Buildings Energy Efficiency in China, Germany, and the United States,” 16.
[2] Economidou et al., “Europe’s Buildings under the Microscope,” 19.
[3] Ibid., 12&75.
[4] Levine, “Building Energy-Efficiency Best Practice Policies and Policy Packages,” 2014, 49.

- Extension of the directive's scope by eliminating the 1,000 m^2 threshold for renovations, meaning that all existing buildings undergoing major renovations have to meet minimum efficiency levels. (Articles 4, 5 and 6)
- Encouragement of the public sector to set an example by establishing more ambitious targets for energy performance.
- Introduction of minimum requirements for components for all replacements and renovations, although, for major renovations, the holistic calculation methodology is the preferred method.

Member states will have to report their specific application of the methodology to the Commission regularly (starting from July 2012). These reports may be included in the National Energy Efficiency Action Plans under the Energy Services Directive (Directive 2006/32/EC). Based on this framework methodology, the EU member states should calculate cost-optimal levels of minimum energy performance requirements using the comparative methodology framework and other relevant parameters, such as climatic conditions and the practical accessibility of energy infrastructure. [1]

Moreover, the EPBD reinforced the requirement that all the new buildings should be nearly-zero-energy buildings (nZEB) by the end of 2020.

GERMANY'S ENERGY OBJECTIVES, CORRESPONDING TO THE EPBD

Over the next several decades, Germany has set the goal to reduce greenhouse gas emissions as follows: 2020: -40%, 2030: -55%, 2040: -70% and 2050: -80% to -95%; all in comparison to 1990 (BMU, 2013a). Furthermore, in 2011, Germany decided to undertake the so-called Energiewende (energy turnaround) whereby plans are made to phase out nuclear power as well as the fossil fuels in the coming years. It is a challenge to be independent from third party-countries, where additional fossil fuels have to be imported for Germany, in order to restructure its own energy market with renewable energies.

This amplifies the need for more Regenerative Energies (RE) in the electricity mix, as well as a strong increase of EEI in all sectors [2].

As outlined in the Energy Concept (Energiekonzept), Germany has set targets to reduce the heating requirements of the building stock by 20% by 2020; and to reduce primary energy consumption by 80% by 2050 (BMWi, 2011) in comparison to 1990. These targets are far beyond the EU EPBD objectives. In order to reach these targets, Germany needs to increase the annual renovation rate of its existing building stock from below 1% to 2% (BMWi, 2011). [3] In the following chapters, the approach will illustrate how Germany is going to implement the EU-guidelines, as well as how it will fulfill its ambitious goals.

[1] Economidou et al., "Europe's Buildings under the Microscope," 73.
[2] Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study - ," 24.
[3] Ibid., 25.

7.2. IMPLEMENTATION INTO THE NATIONAL ENERGY CODES IN GERMANY

Due to the long life and low retrofit rates of buildings in the European Union, implementing appropriate building codes is more important than a significant construction boom. The earlier and tougher such energy codes are implemented, the greater the savings of energy and carbon dioxide emissions (CO_2) are. [1] The Energy Saving Ordinance (Energieeinsparverordnung EnEV) and the Renewable Energies Heat Regulation (Erneuerbare Energien Wärmegesetz EEWärmeG) are the basis to reach these energy saving targets [2]. The building codes are hereby the key driver for implementing energy efficiency measures, where energy-related requirements are integrated during the building´s design or retrofit phase [3].

Several EU member states used to have some kind of minimum requirements for thermal performance of building envelopes in the 1970s, e.g. in some northern countries, thermal insulation requirements already existed since 1948 [4] and that is why European energy-related building codes have historically focused on thermal insulation requirements for building elements like walls and roofs, as well as on the reduction of heating energy consumption. As a result of the EPBD, the national building codes are focusing increasingly on integrated building energy performance rather than prescribing minimum thermal properties of building envelopes, HVAC systems or fenestration [5]. Therefore, energy performance certificates reinforce the implementation of buildings energy certification and audit schemes, which can enhance the value of efficient buildings, as well as stimulate the real-estate market towards green investments [6].

In Germany, leading indicators of potential future targets for energy performance are provided by using research and development as well as demonstration projects that exceeds the prevailing minimum standards by far [7]. Germany´s government has determined an 80 % reduction of the primary energy demand of buildings and to achieve a thermal retrofit rate of 2% by 2050 at the same time, as mentioned above. The government is investigating what role tax support options could play in encouraging thermal retrofits which will ensure the delivery of the necessary energy performance. [8]

[1] Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 51.
[2] Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study - ," 25.
[3] Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 51.
[4] Ibid.
[5] Ibid., 52.
[6] Economidou et al., "Europe's Buildings under the Microscope," 18.
[7] Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 52.
[8] Karsten Neuhoff et al., "Using Tax Incentives to Support Thermal Retrofits in Germany" (CPI Report, Climate Policy Initiative, 2011), 04, http://www.econstor.eu/handle/10419/65870.

7.2.1. BUILDING CODES

Germany´s regulatory instruments support financing retrofitting ambitions. There will be a close association that will have an influence on construction and demolition, which is already the case in modernized new buildings with a very low energy requirement in use. The same goes for buildings that will be built in the future - according to EU´s Directive 2010/31/EU, from 2021 onwards, only nearly-zero-energy buildings may be built in the European Union. [1] Tightening the standard for Germany´s new buildings to climate-neutral by 2020 is essential to meet the Federal Government´s goal of having an almost climate-neutral building stock in 2050.

ENERGY SAVING ORDINANCE (ENERGIEEINSPARVERORDNUNG ENEV)

In 2012, the amendment to the climate-neutral building standard of the Energy Saving Ordinance (Energieeinsparverordnung EnEV) was introduced as required by the recast of the EPBD 2010 [2]. The EnEV distinguishes between residential and non-residential buildings, as well as between existing and new buildings; the EnEV sets clear standards for windows, walls and roofs for new buildings. When it comes to installations on or in buildings that produces renewable energy, the amount of produced energy, under certain circumstances, may be deducted from the final energy consumption of the building allowed under the EnEV. [3] In 2014, the new German Energy Saving Ordinance was about tightening the regulation for 2016 - existing buildings are excluded, but the specifications for new buildings are: -25% primary energy consumption and -20% for the building envelope energy demand. Categories of final energy demand were furthermore added to the German Performance Certificate (Energieausweis) with ratings from A+ to H and as the basis for the new nearly-zero-energy building standards which is setting up step by step. [4]

RENEWABLE ENERGIES IN THE HEAT SECTOR (ERNEUERBARE-ENERGIEN-WÄRMEGESETZ EEWÄRMEG)

Another regulatory instrument is the Promotion of Renewable Energies in the Heat Sector (Erneuerbare-Energien-Wärmegesetz EEWärmeG) for new building projects since 2009, which demands usage of renewable energies for heat supply. A minimum percentage of the building´s heat and cooling supply has to be drawn by renewable energies according to technologies: 15% when using solar, 30% in the case of biogas and 50% when bio-oil, solid biomass or geothermal energy is used or a heat pump is installed. Germany´s federal states can lay down similar requirements for existing structures. The German CO_2 Building Renovation Programme aims towards the urgent refurbishment of old buildings.

[1] Markus Weißenberger, Werner Jensch, and Werner Lang, "The Convergence of Life Cycle Assessment and Nearly Zero-Energy Buildings: The Case of Germany," *Energy and Buildings* 76 (June 2014): 554, doi:10.1016/j.enbuild.2014.03.028.
[2] Economidou et al., "Europe's Buildings under the Microscope," 74.
[3] Zukunft-Haus, 2013 in: Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study -," 25.
[4] Veit Bürger, "The Assessment of the Regulatory and Support Framework for Domestic Buildings in Germany from the Perspective of Long-Term Climate Protection Targets," *Energy Policy* 59 (August 2013): 73, doi:10.1016/j.enpol.2012.06.017.

Loans and subsidies can be required to upgrade existing structures.[1] In 2009, approximately 0.91% of apartments in the residential and non-residential sectors were modernized as a result of the Promotion of Renewable Energies in the Heat Sector regulation. The amount of the annual CO_2 savings in this year was about one million t compared to the existing building stock.[2]

	Building code requirements		Performance based requirements[1]		Prescriptive/element-based criteria in building codes					
	New build	Renovations	New build	Renovations	Thermal insulation	Air permeability	Ventilation requirements	Boiler/AC system efficiency	Lighting efficiency	Other requirements
AT	Y	Y	Y	Y	Y	Y	Y	Y	N	Summer comfort requirements
BE-Wl	Y	Y	Y	N	Y	N	Y	N	N	Overheating indicator should not exceed 17 500kh. T_{in} must be under 26°C for 90% of year in RE. K-values on global thermal insulation of entire building. Thermal bridges
BE-Br	Y	Y	Y	N	Y	N	Y	N	N	
BE-Fl	Y	Y	Y	N	Y	N	Y	N	N	
BG	Y	Y	Y	Y	Y	Y	N	Y	N	
CH	Y	Y	Y	Y	Y	N	N	Y	NRE	Thermal bridges, solar shading, max 80% of demand for heating & DHW covered by non-RES
CY	Y	Y	Y	Y	Y	N	N	N	N	Solar collectors in new RE
CZ	Y	Y	Y	Y	Y	Y	N	BO	N	T_{in} of 20°C in winter and 27°C summer
DE	Y	Y	Y	N	Y	Y	Y	Y	NRE	T_{in} (20-26°C), humidity, air change rate & air velocity requirements
DK	Y	Y	Y	N	Y	Y	Y	Y	NRE	Max T_{in} 26°C. Thermal bridges requirements
EE	Y	Y	Y	Y	Y	Y	Y	Y	NRE	RE & office temperature requirements
ES	Y	Y	Y	Y	Y	Y	Y	Y	NRE	Thermal comfort, T_{in} 21°C (winter), 26°C (summer), mandatory RES use (solar collectors/PVs)
FI	Y	P	Y	P[2]	Y	Y	Y	BO	Y	Max T_{in} applies (typically 25°C). Max CO_2 concentration in indoor air.
FR	Y	Y	Y	Y	Y	Y	Y	Y	NRE	Max T_{in} applies based on a number of factors
GR	Y	Y	Y	Y	Y	Y	Y	Y	N	
HU	Y	Y	Y	Y	Y	N	N	N	N	
IE	Y	Y	Y	N	Y	Y		Y		Thermal bridges
IT	Y	Y	Y	Y	Y	Y	Y	Y	N	

IMPORTANT NOTE

The elements in the prescriptive criteria can act as supplementary demands or as an alternative approach for setting requirements. In some cases they represent embedded elements in the performance-based methodology.

OTHER NOTES

[1] In some cases this may cover only heating demands, and in others it may also include DHW, electricity and other end uses;2 The Finnish legislation allows authorities to decide whether the building regulations will be applied to the renovation or not. New EE requirements will be in place in 2012; 3 Slovenian requirements will be in place from end 2014/beg 2015.

LEGEND

RE: Residential
NRE: Non-residential
Tin: Indoor temperature
DHW: Domestic hot water
AC: Airconditioning system
BO: Boiler
P: Partly
Y: Yes
N: No

Figure 20: Summary of building energy code requirements and prescriptive criteria
Source: [3]

[1] Ibid.
[2] Clausnitzer et al, 2010 in: Ibid.
[3] Economidou et al., "Europe's Buildings under the Microscope," 77–78.

PRESCRIPTIVE-BASED REQUIREMENTS FOR NEW BUILDINGS

The prescriptive element-based requirements associated with building energy codes, such as minimum/maximum indoor temperatures, maximum U-values, requirements for minimum ventilation rates and boiler and/or air conditioning plant efficiency, differs from each EU member state. (see Fig.21) [1].

	MT	CY	PT	GR	ES	IT	LV (1)	FR	BG	BE	NL	IE	HU	SI
HDD (5)	560	782	1 282	1 663	1 842	1 907	1 970	2 483	2 686	2 872	2 902	2 906	2 922	3 053
Roof	0.59	0.85	0.9-1.25	0.35-0.5	0.45-0.65	0.32-0.65	0.2κ-0.35κ	0.2-0.25	0.3	0.3	0.4	0.25	0.25	0.2
Walls	1.57	0.85	1.45-1.8	0.4-0.6	0.57-0.94	0.33-0.62	0.25κ-0.5κ	0.36-0.40	0.35	0.4	0.4	0.37	0.45	0.28
Floor	1.57	2		0.45-0.5	0.62-0.69	0.29-0.38	0.2κ-0.35κ	0.37-0.40	0.5	0.6	0.4	0.37	0.45	0.9
Window/ Door	5.8	3.8		2.6-3.2	3.1-5.7	1.3-3.7	1.8κ-2.4κ	1.7-1.9	1.8	2.5	4.2	2.2	1.6	1.1 -1.6

	UK (3)	RO	DE	SK	CH (2)	DK	CZ	AT	PL	LT	EE	SE (4)	NO	FI
HDD	3 115	3 129	3 239	3 453	3 482	3 503	3 571	3 573	3 616	4 094	4 444	5 444	5 646	5 850
Roof	0.2	0.2	0.24	0.19	0.17 or 0.2	0.2	0.24	0.2	0.25	0.16	0.15-0.2		0.18	0.09
Walls	0.3	0.56	0.24	0.32	0.17 or 0.2	0.3	0.3	0.35	0.3	0.2	0.2-0.25		0.22	0.17
Floor	0.25	0.35	0.3		0.17 or 0.2	0.2	0.45	0.4	0.45	0.25	0.15-0.2	0.4-0.6	0.18	0.16
Window/ Door	2	1.3		1.7	1.3	1.8	1.7	1.4	1.7	1.6	0.7-1.4		1.6	1.0

NOTES

(1) Depending on type of building (residential, public, industrial etc.) where κ is a temperature factor, κ = 19/(Tin-Tout), Tin and Tout denote indoor and outdoor temperatures, respectively.
(2) Depending on evidence of thermal bridges
(3) For England & Wales
(4) Depending on type of building (residential and non residential) & type of heating (electric and non electric). These represent overall U values
(5) Mean HDD values for period 1980-2004 based on Eurostat data

LEGEND
HDD: Heating degree days.

Figure 21: Building envelope insulation requirements
Source: [2]

[1] Ibid., 83.
[2] Ibid., 84.

BUILDING CODE REQUIREMENTS FOR EXISTING BUILDINGS

Article 5 of EPBD only applies to buildings over 1.000 m^2 before 2010. With the EPBD requirements, specific mandatory building codes associated with improving the energy performance of existing buildings, have not yet been reported by all the member states (see Fig.22). [1]

AT	Specific maximum heating energy demand targets for major renovation of residential and non-residential buildings. Values for renovated buildings are around 25-38% higher than new build requirements. Heat recovery must be added to ventilation systems when renewed. Maximum permitted U values for different elements in case of single measure or major renovations. Prescriptive requirements to limit summer over-heating.
BE	Maximum U values and ventilation requirements apply depending on the region.
BG	Regulations requiring performance-based standards of existing housing and other buildings after renovation. Requirements for new and renovated buildings are the same.
CH	Renovated buildings are required to use no more than 125% of the space heating demand of an equivalent new building. A single element approach may also be applicable for renovations.
CY	Minimum energy performance requirements (class A or B) for buildings over 1 000 m^2 undergoing major renovation.
CZ	Performance-based requirements when a building over 1 000 m^2 is renovated. Requirements for new and renovated buildings are the same.
DE	Conditional requirements apply in the case of renovation of components whereby requirements extend exclusively to those parts of the building surface and parts of the installation that are the subject of the measures. Alternatively, a holistic assessment can also be made where values for renovated buildings should not exceed new build requirements by more than 40%.
DK	Component level requirements when existing buildings are refurbished for all improvements or extensions regardless of building size.
EE	Performance-based requirements for all building types when buildings are major renovated. Values for renovated buildings are around 25-38% higher than new build requirements.
ES	Existing buildings over 1 000 m^2 must comply with the same minimum performance requirements as new buildings if more than 25% of the envelope is renovated.
FI	Reference transmittance/heat loss (in W/K) requirements apply. New energy performance regulations will be launched in 2012.
FR	Performance-based requirements for buildings undergoing renovation apply for residential buildings and values depend on the climate and type of heating (fossil fuel/electricity). Requirements for components also apply during building renovation. New renovation requirements for all buildings from 2013.
HU	Performance-based requirements (in terms of primary energy) apply for residential buildings, offices and educational buildings. Requirements for new and renovated buildings are the same.
LT	Buildings over 1 000 m^2 undergoing major renovation must achieve the energy performance standard of a Class D building where D corresponds to 110 kWh/m^{2}a for buildings > 3 000 m^2; 130 kWh/m^{2}a for buildings from 501 to 3 000 m^2; 145 kWh/m^{2}a for buildings up to 500 m^2.
LV	Requirements on different elements are applicable.
MT	U value requirements for existing renovated buildings.
NL	The Energy Performance Standard (EPN) sets requirements for the energy performance of major renovations of existing buildings (expressed as an energy performance coefficient).
NO	Building regulation requirements only apply when the purpose or use of the building is changed at renovation or if considered so extensive as to be equivalent to a new building.
PT	Special requirements for buildings over 1 000 m^2 and over a specified threshold energy cost. A mandatory energy efficiency plan must be prepared and all energy efficiency improvement measures with a payback of less than 8 years must (by law) be implemented. The threshold is based upon 40% of the worst performing buildings by typology.
SI	Minimum requirements apply to major renovations (i.e. if at least 25 % of the envelope is renovated). The requirements apply to buildings of all size (NB the 1 000 m^2 limit is not used). Min. requirements apply for the renovation of heating systems.

Figure 22: Building code requirements for existing buildings
Source: [2]

[1] Ibid., 87.
[2] Ibid., 88.

7.2.2. INSPECTION AND MONITORING

Requirements concerning the control of the building´s design and construction are prior to, during and upon completion of the construction phase. The application for permits, approval of plans, inspection of authority and completion necessarily involve the declaration to authority [1].

The Building Code (BauO) or state building code (LBO) of Germany´s federal states is an integral part of public construction law. According to a legal opinion of the Federal Constitutional Court, the German building law is in the legislative competence of the federal states. Thus, all countries have accordingly enacted their own building regulations. Germany´s building code is supplemented by related decrees, technical implementing regulations and by building inspection established legal norms. All construction and renovation work are governed by the respective building regulations. The local and relevant authorities are responsible for monitoring, granting and setting the action and considering the substantive conditions for the establishment, modification and demolition of installations. The building regulations also contain provisions concerning the final acceptance, the tasks of supervision for constructional safety, acoustics, thermal insulation and fire protection. [2] The building code process is used to prevent threats arising from violations of the law, particularly by unlicensed construction of buildings, unauthorized conversion, unauthorized change of use, unauthorized demolition or by deviations from the provisions of the building permit and the lack of conservation constructed facilities that pose a danger.

The following standard powers of audit can be claimed by the building code authorities:

- Directive for a building freeze
- Adoption of a ban on use (to undo the change in use or to adjust any use)
- Adoption of remedy

If the violators do not comply with the arrangements of the building code authority, they may be impended with penalty payment, execution by substitution or coercive detention by substitution. In addition, the building authority can also set fines that do not serve to eliminate the illegal states, but which is imposed as a penalty caused by the violation of administrative offense. [3]

NUMBER OF COUNTRIES WITH PENALTIES FORESEEN FOR EPC NON-COMPLIANCE

It is 18 member states with penalties next to 11 member states without penalties foreseen in the event of non-compliance with the certification process. In most member states, residential EPCs typically cost between 100€ and 300€, while the full cost range is

[1] Ibid., 89.
[2] BMJV and JURIS, "Gesetze Und Verordnungen Deutschlands," *Bundesministerium Der Justiz Und Für Verbraucherschutz*, n.d., http://www.gesetze-im-internet.de/bbaug/.
[3] Ibid.

between under 50€ and 2,000€. The information on costs for non-residential buildings is scarce. The quoted values range from 0.5€ to 3.0€ per m^2. In monitoring and analysing the opportunities for energy performance improvement, it has been proven that these registers will be very useful if they are available and they will also prove invaluable in assessing trends in energy performance in the longer term. [1]

7.2.3. CHALLANGES & BARRIERS OF IMPLEMENTATION

LACK OF FINANCIAL MEANS

The provision of sufficient finances is one of the main problems when it comes to the implementation of energy efficiency in the building sector. A lot of financing needs are derived from the private sector, since most German houses are not owned by the state. Depending on the specific situation, the costs for retrofitting may differ exceptionally. [2] Retrofitting costs that are exclusively energy related ranges from 80 to 230 €/m^2. In single-family houses for example, the general modernization plus energy related renovation costs per m^2 are much higher than in multiple family houses. [3] This is caused by the greater outer wall area of single family houses in relation to the living unit compared to multiple family houses [4].

LANDLORD-TENANT PROBLEM

60% of the residential house owners do not live in their houses themselves [5]. As a consequence, it is the tenants who benefit from the retrofit energy savings, whereas the owner´s motivation for retrofitting therefore remains low. According to § 559 BGB, the landlord is allowed to increase the annual rent by a maximum of 11% of the costs of the modernization measures to incentivize owners to invest in energy efficient renovation. Since the cost for electricity and heating would decrease due to the improved insulation, the warm rent would not be affected by an increase. Lower-income-families are at disadvantaged especially, since the increase of the warm rent is not always the case. [6]

MARKET BARRIERS

To increase energy efficiency, market-stimulation tools are necessary as well as the establishment of a tender-model for measures, which must be equipped with sufficient volume of financial promotion in order to improve energy performance of households and KMUs (medium-sized enterprises). [7]

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[1] Economidou et al., "Europe's Buildings under the Microscope," 69.
[2] Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study - ," 25–26.
[3] Ifs, 2012a in: Ibid., 26.
[4] Ifs, 2012b in: Ibid.
[5] Henger & Voigtländer, 2012 in: Ibid., 14.
[6] Ibid., 26.
[7] Prein, "14-06-02_Pressegespraech_EU-EnEffRicht_Hintergrundpapier.pdf," 3.

SOCIAL BARRIERS

In order to achieve all the buildings´ ownership structures, successful campaigns have to be institutionalized and extended in order to reach all areas such as the rental housing area and the non-residential buildings. [1]

[1] Ibid., 8.

7.3. BUILDING ENERGY LABELLING

7.3.1. MANDATORY STANDARDS

ENERGY PERFORMANCE CERTIFICATES (EPCS)

The European Union introduced Energy Performance Certificates (EPCs) that supply specific data about the energy performance of the building to owners and tenants by displaying the energy performance of a building with a comparison label, similar to the EU Energy Efficiency Label. In first row, EPCs were implemented to lower CO_2 emissions but the effectiveness of EPCs is in dispute because they are not applicable for most of the buildings due to their legal status, since there are two different legal regulations for new and existing buildings. The display of the EPC is mandatory for new buildings, while for existing buildings, the EPC is only mandatory upon request by the purchaser or tenant due to EnEV 16 (Energieeinsparverordnung). Furthermore, these certificates do not make a statement about the financial implications of energy efficiency, which seems to be the main attraction, and is therefore only a minor purchasing criterion for apartment purchases. But in general, the awareness towards energy efficiency is rising, the performance certificate provides information on cost-efficient renovation methods and energy efficiency as an investment which can be can be translated into higher property value. On the other hand, the positive impact of energy efficiency labels cannot play the same role for buildings as for electronic appliances. Although energy efficiency is visible for purchasers, the housing market is demarked by scarcity and heterogenity in contrast to the household appliance market. [1] As a result to the new European Energy Performance of Building Directive (EPBD), the use, relevance and trust of the EPC will likely be increased [2].

7.3.2. VOLUNTARY STANDARDS

GERMAN SUSTAINABLE BUILDING COUNCIL (DGNB)

The basic system for assessing sustainability performance of buildings was jointly developed by the DGNB and the Federal Ministry of Transport, Building and Urban Affairs (BMVBS) in 2009. While the BMVBS has precisely specified this basis for the self-evaluation of federal buildings, the DGNB developed a full certification system for buildings and urban districts. The DGNB building certification system provides an objective description and assessment of the building´s sustainability by 50 sustainability criteria ranging from the quality sections of ecology (22.5%), economy (22.5%), socio-cultural aspects (22.5%), technology (22.5%), process work flows and site (10%). The quality of the building is assessed comprehensively over the entire life cycle of the building. The DGNB system, which can be applied internationally, is based on

[1] Hermann Amecke, "The Impact of Energy Performance Certificates: A Survey of German Home Owners," *Energy Policy* 46 (July 2012): 4–5, doi:10.1016/j.enpol.2012.01.064.

[2] Ibid., 13.

voluntarily outperforming the concepts that are common or usual nowadays. [1]

The performance of a building gets certificated by the three DGNB awards in bronze, silver and gold. The building will receive a bronze DGNB certificate if the total performance is of at least 50%; a silver certificate is granted with a total score of at least 65%, a gold certificate requires a total score of at least 80%. A pre-certification during the planning phase is an option that will help reach the energy efficiency goals of the project. [2]

There are defined target values for each criterion, where up to ten assessment points can be awarded for reaching these target specifications. Some criteria are weighted differently. The combination of the assessment points with the relevant weighing is the basis for the calculation of the concrete score for the six quality sections. The total score for the project is calculated from the five quality sections based on their weighing. The separately considered quality of the site is included in the marketability criterion, whereas in the certification of urban districts, the site quality is incorporated in all criteria. [3]

The energy efficiency labelling programs of most EU member states utilize a number of different scales associated with different building types. The German DGNB certification system currently certificates 13 different types of buildings as well as whole urban districts since 2011. At present, the DGNB certification system is available on national as well as on international level with its more than 20 user profiles. The comprehensive portfolio ranges from new construction of office and administrative buildings, retail buildings, residential buildings and mixed-use buildings to existing buildings. [4]

PASSIVE HOUSE STANDARD

In 1990, the first Passive House was built in Darmstadt in Germany, which represents the oldest voluntary standard for super-efficient buildings in Europe. This very first Passive House consumed 90% less space-heating energy than a new standard building did back then. An estimated 32.000 Passive Houses have been built worldwide since then, with the main concentration in Germany and Austria. The European Union also provides a Passive House Standard for retrofitting. [5]

[1] "DGNB Homepage," 2015, http://www.dgnb-system.de/en.
[2] Ibid.
[3] Ibid.
[4] Ibid.
[5] Passive House Institute, 2011 in: Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 60.

7.3.3. CHALLENGES AND BARRIERS

To inform consumers about the options they have to improve the energy performance ratings of the building they are about to rent or purchase, is one main goals of implementing a building EPC scheme. How to determine whether higher-related buildings are sold or leased at a cost premium, is hereby a legitimate question. The Netherlands and Poland are the two countries in Europe who have investigated the impact of EPCs on market prices [1]. 40,000 out of 180,000 houses in the Netherland´s study had an energy label. A positive cost premium of 2.7% was found in this study. In the Polish study, which was an opinion survey that was done before the EPC implementation in Poland, 60% of companies interviewed believed that the EPC would have a positive effect. [2]

DURATION OF CERTIFICATE VALIDITY

The EPBD states that the validity of energy efficiency building labels should not be longer than 10 years. Most member states have chosen this frame for mandatory recertification and a few states opted for shorter periods, mostly between five and ten years. [3] The DGNB certificate lasts for five years [4].

CERTIFICATE QUALITY

A good quality assessment guarantees a successfully implemented EPC system. The auditor can be penalized by withdrawal of his or her accreditation or by a fine if a quality check finds that a certificate was poorly or deficiently estimated. [5] The DGNB license can be revoked from the auditor by DGNB if the documents for the conformance testing are repeatedly inadequately submitted to DGNB. Inadequately prepared documents are when the calculated overall result of the auditor differs more than +/- 5% from the DGNB, or if the documents do not meet the requirements of the DGNB. [6]

[1] Engel & Thomsen & Wittchen, 2010 in: Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 74.
[2] Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 74.
[3] Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 73.
[4] "DGNB Homepage."
[5] Levine, "Building Energy-Efficiency Best Practice Policies and Policy Packages," 2014, 74.
[6] "DGNB Homepage."

7.4. INCENTIVES

The role of available financial programs and innovative mechanisms become more important as Europe strives towards an increasing building energy performance [1]. Germany´s economic instruments with its regulatory policies through funds via the Kreditanstalt für Wiederaufbau (KfW) and Federal Office of Economics and Export Control BAFA are set in relation to the building standards. Income tax reductions were discussed as a support for retrofitting projects, but have been blocked in the Federal Council by the federal states due to the loss of tax income this would have caused. Meanwhile, tax reductions are again discussed as an alternative to KfW funding for house owners [2]. But apart from this current discussion, the KfW program have an impact on the increasing awareness towards energy savings in buildings [3].

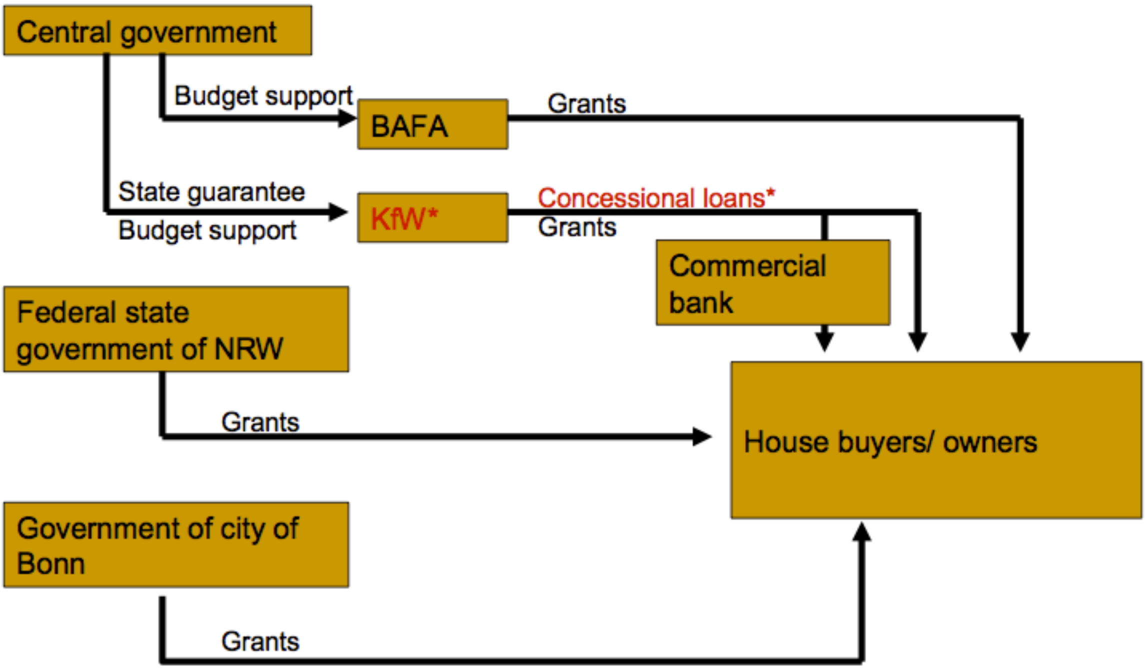

Figure 23: Financial support channels and flows for EEI in buildings in Germany, e.g. specified for the case study of the city of Bonn.
Source: [4]

[1] Economidou et al., "Europe's Buildings under the Microscope," 13.
[2] Bundesrat, 2013 in: Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study -," 33.
[3] Kuckshinrich et al. 2012 in: Ibid., 32.
[4] Ibid., 29.

7.4.1. PUBLIC FINANCING

The German government has declared to provide 1.5bn EUR annually in form of loans and grants as commitment authorizations for KfW programs on energyefficient buildings for the period 2012 to 2014 [1]. The German Bank of Reconstruction (KfW) is Germany´s state owned bank, which is 80 % owned by the national state and 20% owned by the federal state. The provision of low interest loans is the main instrument of KfW, although in certain cases, specific grants are also provided. For the KfW´s credit lines, various repayment periods are possible, whereas different conditions apply to the loan dependent on the period taken. [2]

Building standards, which are oriented along the minimum requirements of the EnEV, are applicable to all funding programs of KfW like the KfW house 55/70, 85/100, 100/115 as well as the building standard for historical monuments. The standard 55 describes the currently highest standard of a house that requires 55% of the energy needed, which fulfills the EnEV minimum requirements. [3].

On the other hand, all funding provided by BAFA, which belongs to the Federal Ministry of Economics and Technology (BMWi), is in the form of grants. Here, the funding applications can go directly to the BAFA and do not need to go via the private bank like the KfW-loans. The focus of the BAFA funding is on the promotion of energy efficiency as well as on the use of renewable energy. The BAFA fundings are part of the "Market Incentive Programmed for Promotion of the Use of Renewable Energies (MAP)". [4]

GERMANY - LOANS AND SUBSIDIES FROM THE RECONSTRUCTION CREDIT INSTITUTE, KFW

A central role concerning the promotion of the building sector´s energy savings and CO_2 reduction is played by government-owned banking group Kreditanstalt für Wiederaufbau (KfW). Subsidies and loans for new buildings, as well as energy efficient retrofitting that meet the requirements of an efficient building (Effizienzhaus), are offered by KfW. Subsidies for at least 3.1 million homes were implemented between 1990 and the end of 2009. The total subsidies amount in 2009 was 16.9 billion EUR, of which 10.6 billion EUR was for energy efficiency and 6.3 billion EUR for renewable energies. [5]

[1] BMVBS, 2013 & BMF, 2013 in: Ibid.
[2] Ibid., 29–30.
[3] KfW, 2013b in: Ibid., 30.
[4] Ibid.
[5] Economidou et al., "Europe's Buildings under the Microscope," 93.

FINANCIAL SUPPORT FOR NEW BUILDINGS

The KFW funding program No. 153 focuses on new buildings that fulfill the passive house standard. Low interest loans are provided with a subsidised interest rate in the first ten years. [1] The construction of approximately 84,000 apartments has been realized with the support of this program in 2010. This amount of apartments constitutes approximately half of the newly built apartments in 2010, followed by a slightly decrease in 2011. [2]

FINANCIAL SUPPORT FOR THE RETROFIT OF EXISTING BUILDINGS

In 2011, 180,000 apartments received support for energy efficiency retrofitting measures, which results in a remarkable decrease in the amount of renovated apartments compared to 2010 and its 340,000 retrofitted apartments through KfW programs [3]. The level of the investment grant depends on the achieved energy efficiency. The program No. 151/152 was implemented for individual retrofitting measures or full retrofitting of existing buildings that provide low-interest loans as well as repayment grants in the case of full retrofitting. [4] Furthermore, this program is convenient to initial buyers of a newly retrofitted energy efficient building [5]. Applying for an investment grant (No. 430) for the full or partial retrofitting of existing buildings is also an alternative [6]. If a fully or partially retrofit of buildings of municipal or social infrastructures are in line with energy efficiency standards for new buildings, including the passive house standard, the KfW program No. 218/219 will provide loans or repayment grants to municipalities or municipal or local authorities or certain types of businesses [7].

FINANCIAL SUPPORT FOR SOLAR THERMAL INSTALLATIONS AND CHP PLANTS

The programs that are specially focused on the use of renewable energy for heating in buildings are closely linked to the EEWärmeG. KfW supports small scale as well as large scale renewable energy heating systems. KfW program No. 167 provides low-interest loans to home owners or home buyers for exchanging or upgrading their heating systems [8]. For large scale heating systems, low-interest loans are provided to support large scale solar panels, biomass installations, heat based CHP plants as well as large scale pumps [9].

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[1] KfW, 2013e in: Greenovation Hub and Germanwatch, "Financing in Energy Efficiency in Buildings in China and Germany - a Scoping Study -," 31.
[2] Diefenbach et al., 2011/2012 in: Ibid.
[3] Diefenbach et al., 2011/2012 in: Ibid.
[4] Ibid.
[5] KfW, 2013c in: Ibid.
[6] KfW, 2013d in: Ibid.
[7] KfW 2013f/2013i in: Ibid., 32.
[8] KfW, 2013g in: Ibid.
[9] KfW, 2013h in: Ibid.

BAFA programs support solar thermal installations on existing buildings as well as the financing of energy efficient heating pumps by providing grants to private persons and municipalities. When it comes to new buildings, only innovative projects of solar thermal installations get supported by BAFA. [1]

7.4.2. PRIVATE FINANCING

The various KfW-funding programs for energy efficient new buildings and renovations totaled at 6.6 bn EUR in 2011, which further initiated investment of up to 18.6 bn EUR [2]. The directly triggered investment and an upper limit of potentially triggered investment with low occurrence probability are the two different types of triggered investments [3]. The KfW funds of 6.6 bn EUR in 2011 directly triggered an investment of 8.9 bn EUR in addition. The potential upper limit of triggered investment was 18.6 bn EUR. The amount of funding provided through BAFA within the MAP market incentive program (Marktanzreizprogramm) and the private triggered through these public funds are displayed in the following Fig.24.

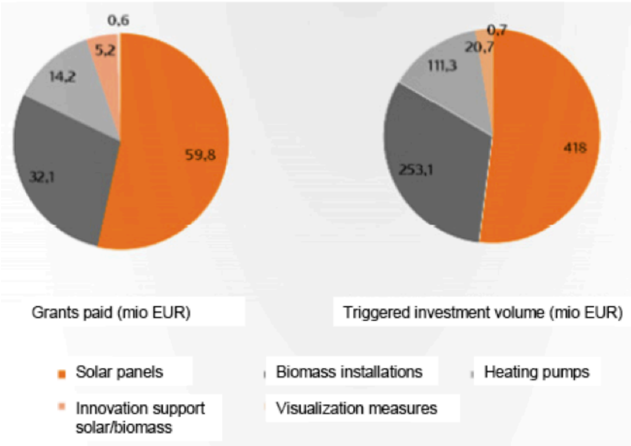

Fig.24: Grants provided through BAFA programs in 2011 and triggered investment
Source: [4]

[1] BAFA, no date a&b in: Ibid.
[2] KfW, 2012 in: Ibid., 33.
[3] Kuckshinrich et al., 2012 in: Ibid.
[4] Ibid., 34.

8. RESEARCH RESULTS AND DISCUSSION

8.1. Comparison of Energy Objectives between China & Germany

FINDINGS

China and the European Union are both stretching over a wide range of different climate zones - China is made up of 22 provinces and the EU is made up of 27 member countries. As a result, there are similar requirements regarding a wide range of temperature and humidity levels as well as authority levels and aged growing building stock in rural and urban areas. Different shares and building types like single-family houses or multi-family dwellings can be found in both countries. Of these facts, different approaches for energy objectives and implementations are already in place but there are needs to be improved.

Regarding the governing system, the EU-Commission and the Chinese Centralized Government share similarities in terms of a higher-level control which could give recommendations as well as codifying new laws that are binding to all member countries and provinces.

Based on the upper mentioned needs, both "united" countries have set up responsible institutions that are controlled on a national level such as the Ministry of Housing and Urban-Rural Development (MORHURD) in China and the Energy Performance Buildings Directive (EPBD) in Europe.

These institutions are responsible for implementing policies at national level in order to reach the overall energy objectives of each country, which are quite different when comparing China and the EU. The Chinese national goal of Green House Gas (GHG) reduction is 40-45% by 2020 in comparison to 2005. The EU national overall goal of 80-95% by 2050 is part of its road map to a low-carbon economy. Germany went one step further and set the goal of a 80% primary energy demand reduction by 2050 for the building sector; ensuring that all new build non-residential buildings are climate neutral by 2020 and increasing the thermal retrofit rate to 2%.

ISSUES

In order to reach those goals, it is indispensible to set specific actions suited to the certain circumstances to get the root of the problem.

Market barriers and administrative bottlenecks should be eliminated by national governments to disburden the renovation of the housing stock. As a result, significant economic benefits will be generated for both countries´ societies by improving the energy efficiency of buildings. Furthermore, the building sector is most affected by the economic downturn and the energy efficiency efforts will show an important impact in terms of employment in the construction industry. These ambitions of improving the energy performance of buildings will therefore generate a positive force for economic recovery as well as investment in a sustainable building stock.

An important tool to understand the energy performance of the building stock in both countries and its changes overtime is the establishment of a centralized database that records information on issued building labels. Benchmark tools and other supportive materials can be developed through using such database. Moreover, important feedback loops can be generated for the building auditors and governmental institutions, provided by the information in the database. As a consequence, the quality of building codes and labelling systems like EPCs will continually be improved to ensure that the recommendations that accompany EPCs are applicable and up-to-date.

In order to improve the regulation framework continuously and to ensure that all member states are up to date, like in the EU, regular and transparent code revision cycles need to be addressed. Tougher building codes than mandated have regularly been set in Germany and Denmark with two to five years between the next update. Revisions are announced well in advance to prepare the industry for the next round of regulation as well as research, development and demonstration projects that far exceed the prevailing minimum standards; these are essential for providing leading indicators of potential future targets for energy efficiency architecture.

8.2. Comparison of the Building Codes between China & Germany

FINDINGS

In order to reach these energy objectives, the approach of the EPBD is to try to harmonize the 27 member states of the EU by a collective mandate based on a whole building approach, the so-called "performance based approach", which is codified by law to all member states since 2006. In 2003, China started to implement the law that all new residential buildings in the HSWW zone have to reach an EEI of 50% compared to a specified building type of the 80s. In 2010, this implementation got adopted in the Sever Cold and Cold zones, as well as the Hot Summer and Cold Winter zone and needs to have an energy improvement of 65%, again compared to buildings of the 80s. In contrast, the EPBD approach regulates overall key targets that are binding to all member states. These overall key targets have to be implemented in the member´s national law and they need to get reviewed every 5 years in order to monitor, adjust and to keep them relevant. The EPBD approach is therefore structured as an overall building approach, where a minimum energy performance level for new constructions is set. In contrast to China, the approach for large existing buildings in the EU that undergo "major renovation" over 1,000 m2, was eliminated after the first review in 2010 and got binded to all buildings of every type. In China, it still differs according to the building use. But the main difference and the driving force of the EPBD regulations are the energy performance certificates (EPCs), which are mandatory for each building in the EU, illustrated in Chapter 7.3. In China, it is remarkable that in 2005 a national design standard for commercial buildings in all climate zones was implemented, similar to the EU-approach, but both, commercial and residential building design standards cover almost only building envelopes and the heating demand. Lastly, the overall national standard for commercial buildings is a document to implement a harmonized and simplified code system, which could covering all five climate zones as well as the potential for creating a simplified overall building code system, which could be applied to China as well.

Specific policies, standards and regulations to constrain meaningful codes efficiency regarding different climate zones, construction conditions, technology as well as materials, already exist in both countries, as mentioned above. Compared to Germany with the "whole building" approach, which is related to a total energy use per unit and the binding conversion by all participants' states. China is continuing to adopt foreign codes as guidance to develop Chinese specific codes.

Unfortunately, the adoption of foreign building codes hardly fit to China´s challenges in the field of energy-efficient architecture. There are three residential building energy efficiency design standards, covering four out of five climate zones, which are a result of the heating reform of the 90s, initiated by MOHURD. This Conservation Law with its building energy efficiency design standard system refers somehow only to a reduction target for heating energy consumption relative to a baseline of the 80s, that covers most of the time only the building envelope and fenestration. In 2001 and 2003, rating and simulation systems was implemented for the Hot Summer Cold Winter and Hot Summer Warm Winter zone, which developed two approaches. The first approach requires a 50% reduction in heating and air conditioning energy consumption in relation to a reference building of the 80s with the same conditions. The second approach sets a maximum permissible heating and cooling energy consumption per m^2, which refers to the heating and cooling degree-days of the project site. Hence, there is a standard for energy efficiency retrofits from 2000, in addition to the design standard boiler systems and outdoor pipe networks. In Germany, the code system differs between residential and non-residential buildings with an addition in the renovation area, with mandatory code regulations for thermal insulation, air permeability, ventilation requirements and boiler/AC system efficiency as well as for non-residential lighting efficiency that are unified over the whole country and further adopted in each EU-country by its own national laws.

ISSUES

The German government already passed its intention for an adapted version of the National Energy Efficiency Law, based on the EU-Guideline. It is necessary as a long-term initative, to simplify regulatory instruments and to arrive at a uniform nationwide implementation, concerning China´s rural areas. Compared to China, with its several building codes referring to different climate zones and a baseline value of a "typical" inefficient building of the 1980s, it is indispensible to review and adjust building codes in a certain period, in order to meet current needs and to react on potential poor working codes, like the EU EPBD model.

There is a wide variation in the way member states have set their whole-building performance standards. Due to the fact that there is no simple and fair method available to compare the different national requirements, the European Union recognizes a necessity in harmonizing these standards. To help each member state compare current code energy performance levels with cost optimum levels, a methodology and guidance for calculating cost-optimal levels of minimum energy performance requirements for buildings has been published by the European Commission in 2012. As a result, this will enable evaluation of progress towards cost optimum policies within each country.

Dealing with 27 member countries with their different cultures, languages and experiences, makes it a unique issue in the EU region when it comes to harmonization of standards. But efforts have already been successful in implementing a platform for communication among professionals and practitioners by the European Union. Helping these professionals share their experience has enabled an effective way to converge some harmonized definitions, methodologies and standards. The more these communication platforms are organized for specific actors, the more success can be generated.

The European Concerted Action (CA) is such a specific network restricted to policy makers in charge of preparing technical, legal and administrative building energy policy, which created a gateway for country representatives to exchange and learn from others on different issues of energy performance of buildings policy implementation.

In order to review and study the effectiveness of these European approaches with its comparable conditions and needs, this way of dealing with a wide range of challenges could be a big advantage for China as well, which will result in the adjustment of its already existing system to a more efficient one, based on the good performance and aligning points. China, as an overall centralized governmental system, can more easily implement and review centralized guidelines with its 5-year plan approach. Modifications can be codified and adjusted in regular periods, which is also an advantage in terms of the administrative maintenance and introduction of a “new” system.

8.3. Comparison of Inspection and Monitoring between China & Germany

FINDINGS

In both countries, China and Germany have building control requirements to, during and upon completion of the construction phase that require declaration to authority, application for permits, approval of plans, inspections by authority and completion of certificates after final completion. These requirements can be a critical step for ensuring regulation enforcement and even for safety-ness during construction and after completion. In China, MOHURD has implemented the “Three level Inspection System”, which is similar to the German model, where the national level transmits certain responsibilities to the local governmental level. In China, only big constructions, e.g. over 50.000m^2 on residential, or over 30 million RMB, schools, cinemas and stadium buildings and buildings supported by foreign aid and loans, are directly monitored by national level, in terms of drawing and construction inspections. All the others get passed down to the local authority and randomly selected by MOHURD for annual random inspections. In Germany, all construction and renovation works are governed by the respective building regulations. The local and pertinent competent authorities are responsible for monitoring, granting and setting the action as well as considering the substantive conditions for the establishment, modification and demolition of installations. The building regulations also contain provisions concerning the final acceptance, the tasks of supervision for constructional safety, acoustics, thermal insulation and fire protection. This system overlaps with the second Chinese validation system, the so-called “Loop System”. There are almost the same responsibilities with the difference, that the German system has a general validity for all constructions, whereas the Loop System only refers to new constructions. If the construction during an inspection doesn’t match the approved plans in the Loop-System, the authority is allowed to impose penalty or to stop the construction till the lack of compliance is remedied. By the German construction law, authorities are able to enforce a building freeze, adopt a ban on use (to undo the change in use or to adjust any use) and adopt of remedy; they are also allowed to threaten coercive like penalty payment.

Hence, there is a big gap between the code compliance rates, controlled and monitored by MOHURD. In 2001, there was a 5% design compliance and 2% construction compliance, while in 2004, 54% design compliance and 20% construction compliance, and up to 95% compliance for both in 2010. However, these values do not represent the overall improvements in code compliance. It rather represents a small cut out, caused by only random site inspections, over all constructed buildings, caused by lacking financial resources for monitoring through MOHURD and local governmental institutions, compared to Germany, where every construction has to be monitored by the responsible governmental institution. To strengthen the loop inspection system for code implementation, the improved code compliance can be linked, establishing stricter non-compliance penalties and instituting a detailed Code of

Acceptance checklist for inspections in the final project approval phase; it can also be encouraged by stronger financial subsidies.

ISSUES

Monitoring has to be more improved, as well as Germany´s objective to create an overall building catalogue in form of a centralized database. This will lead to a better understanding of the energy performance of the building stock. For enhancements and adjustments on building codes, the information in the database provides an important feedback loop. Furthermore, building auditors, for example ESCO companies, will continually improve the quality of EPCs as well as the information in the database ensures that the recommendations that accompany EPCs are relevant and up to date.

These actions could create a tool, making standards in both countries more effective, along side an increased training (of code officials, builders, and other building professionals) and the rigorous updating of the standards to promote the development and use of a new, efficient technology.

In order to counter the perception that energy saving renovation measures comes with a price premium in both countries, the enforcement of compliance with building codes and standards is essential. This process through a qualified workforce can be controlled by proper monitoring of compliance, enforcement and quality, which should be part of any policy package that promotes deep renovation and new construction. However, a significant barrier in reaching the estimated energy savings potential is the relatively low compliance level in both countries.

In 2002 the European Union required all member countries to design national systems for energy certificates and labels for buildings in the next four years (by 2006). Subject to criteria that were established, each country could design the certificates and labels for their own circumstances. The use of certificates was mandatory. By 2008 labelling and certification programs were widespread throughout the EU. Evaluations have been carried out since 2010 using a common methodology across EU member countries.

The EU program for certifying and labelling energy use in buildings is unique among large regions for being both widespread and mandatory. It may turn out to be the most effective policy approach for encouraging retrofitting of buildings in general and at point of sale.

8.4. Comparison of Building Energy Labelling between China & Germany

FINDINGS

MANDATORY LABELLING

In the EU, compared to the voluntary systems, the binding regulatory by the Energy Performance of Building Directive EPBD caused the implementation of mandatory Energy Performance Certificate (EPC). In order to make energy efficiency of buildings more visible for purchasers, the housing market is demarked by the scarcity and heterogeneity in contrast to the household appliance market. Compared to China, implementation of energy labelling started in 2008 by MOHURD and therefore energy labelling in China is comparatively new, it is possibly also a document of the no-mandatory-labelling standards yet. In the EU, as mentioned above, the EPCs are the most powerful tool of the EPBD in order to reach the national energy saving objectives. They are mandatory for all new build buildings, while for existing buildings, the EPC is only mandatory upon request by the purchaser or tenant. EPCs don´t provide any statement about financial implication for energy efficiency but gives information on cost-efficient renovation methods and energy efficiency as an investment which can be can be translated into higher property value. In Germany, the awareness towards energy efficiency is rising due to the EPCs because via the mandatory labelling, the energy efficiency of a building is visible for every purchaser and as a result, the trust in EPCs will likely be increased.

VOLUNTARY LABELLING

Voluntary international green building labels such as LEED, which shows a robust growth in the international market, are widely known. They are available in China as well as in the EU and Germany. These voluntary international green building labels are market competitive compared to the recently implemented Green Building Energy Program GBEL & Building Energy-Efficiency label BEEL in China, or the German Sustainable Building Council (DGNB) and the Passive House Standard. The commonality of these labelling programs is the fact that they reflect almost all actual and theoretical operational consumption related to the building design. In contrast to the LEED requirement of a combined score that enables good performance in one category to offset poor performance in another one, they must meet all criteria for labelling by meeting minimum scores for each category.

The GBEL label has a lot of similarities to the German DGNB standard, which are both standards with rating criteria in sustainability, ecology, economy and technology, but with the difference, that the DGNB also reflects the socio-cultural and entire life-cycle of the buildings. Like the GBEL standard, the DGNB standard refers also to civil buildings and is furthermore available for 13 different types of buildings and whole urban districts on national and international level. A Chinese rating system which refers to whole urban districts would be an important point in China´s fast growing construction, where whole quarters and districts get demolished and newly build.

There is still a lack of knowledge of specific software, materials and technologies among professionals in China´s building industry and about applying these labelling systems of acceptance to monitor compliance from designers to constructors, as well as to inspectors.

GENERAL ISSUES

A few areas for more research have been identified to help improve the impact of labelling programs in the European Union and in order to adjust them to the needs of the different countries, e.g. the increasing retrofit rate etc. As a basis to estimate a buildings energy performance as well as in order to understand the factors that are leading to differences in measured and calculated results, much more research is needed in the field of user behavioural, engineering and statistics.

ISSUES IN MANDATORY LABELLING

In contrast to the EU, where each EU country has adopted its own mandatory label design in order to reach the EU objectives, it could be a great advantage for China to create an own mandatory overall labelling system. Evaluating the rate of public acceptance of labels among EU countries could furthermore help to understand how different designs affect the consumer´s behaviour. In both countries, China and Germany, it is also necessary to enforce the research in order to understand how building owners´ decisions affect the investment of a building´s improvement of energy efficiency performance in order to reach the distinct energy objectives and directions for the building stock development.

Control and enforcement is an important point, when considering the implementation of EPCs, which could be enforced by introducing certified energy service companies (ESCOS) for building labelling.

ISSUES IN VOLUNTARY LABELLING

For China´s energy efficiency policy, building energy labelling programs is a new area compared to the EU and a number of challenges need to be worked out. To prevent consumer confusion that is already evident, a differentiation of the two programs is needed. The advantages and disadvantages of the Chinese five-star green building rating system and the international LEED green building rating system are not comprehensible to the customers.

Specific training of the affected fields like the Chinese government, exhorted builders to participate in the green building labelling program, starting from the program´s inception in 2008 until 2011. Back then, a high number of professionals in the private sector, construction sector as well as in design institutes were introduced to the techniques for meeting label levels of three up to five stars. To support the government´s goal of 1 billion m^2 of new green buildings by 2015, the second phase of this program was initiated in 2011, which provides government incentives for qualifying buildings at the two-star level or above.

Compared to the voluntary labelling programs, the most powerful combination exists out of mandatory national directions like the EPBDs implemented with certification tools e.g. Energy Performance Certificates e.g. EPCs, codified by law in combination with additional financial incentives in order to work out a functioning system of compliance control. Furthermore, this approach would deliver a clear picture of the actual condition of a building stock.

The attendance to make the necessary investments increases with the confidence of consumers and investors into the quality level of renovation measures that must be re-established.

8.5. Comparison of Incentive Programs between China & Germany

FINDINGS

When financial fundings become evident, both countries provide large amounts in order to stimulate different areas in the construction market. In China, funding are provided by the central government to the local government, to project developers or directly determine it into retrofitting measures. In contrary to Germany, where funding is provided to house owners or buyers directly in the manner of concessional loans and even grants.

It is a sign of success that in Germany 340,000 retrofits have been completed in 2010 using private and governmental funding. It is remarkable that 78% of the investors used neither the KfW nor the BAFA programs; last ones are mainly responsible for Renewable Energies (RE). Further in 2010, approximately 84,000 newly built apartments have been constructed with these funding, which represents almost half of the overall constructed ones.

Comparing the same point, China´s 150 million m^2 retrofit target as well as the 50 million incandescent lamp replacement target of heating retrofit and efficient lighting subsidies, exceeded their goals. A meaningful portion of the up-front costs of efficiency measures, e.g. 15% to 20% of total energy retrofit costs, are being covered by China´s building efficiency incentives. Large investments from the central government as well as some innovative local cost-sharing mechanisms made these incentive amounts possible. Regarding the big amount of households only installing a heat meter rather than carrying out the whole retrofit program including the envelope and heat supply network retrofits, despite being given comprehensive retrofit incentives, the savings per m^2 achieved from energy retrofits reflect only half of the target.

ISSUES

Due to the fact that in Germany, 78% of the program participants are using funding for non Renewable Energy technologies, this development depicts the attitude of decision makers to invest in EEI of the main building structure than in new building equipment or technology, represented by “private” funding of the KfW.

Leveraging private investment

A key to successful government energyefficiency incentives is to leverage private investment, particularly in developing countries where private investment for these purposes is limited. China used to be successful in leveraging for Energy Efficiency (EE) in industry. But its programs like the Green Credit Policy, launched in 2007, are still in an early stage and the CHUEE (Chapter 5.4) are still in a wait-and-see position with the banks. There is a demand of leverage in the residential building sector, compared to the German KfW bank. The demand and promotion of energy service companies (ESCOs) should be increased. These energy service companies are providing market stimulation by their business model itself by offering EEI services, which get paid by themselves due to the energy savings over a long term.

It is all about the creation of appropriate financing schemes that can help enabling the success of deep renovation programs. These financing schemes need to address all the categories of private and commercial real estate owners as well as they need introducing measures using appropriate subsidies, low-interest and longer term loan schemes and other financial incentive schemes.

9. Conclusions & Future Research

Regarding the question, if energy policy can be justified and implemented more aggressively in order to accelerate the development to build new energy efficient buildings and to retrofit existing buildings in a more energy efficient way? It is necessary to provide the groundwork for policy makers to make decisions regarding future code revisions and adjustments.

In order to reach the energy objectives of each country, it is necessary to increase the effectiveness of building energy standards set by governmental organizations, in the following points:

- Irrespective to China's country size and different climate zones, this work would recommend to unify the building code system with an overall approach like Germany and the EU did; with a performance-based approach with a maximum energy consumption value per m^2.
- For example, executed by a centralized authority like the Ministry of Housing and Urban-Rural Development (MOHURD), which is similar to the Energy Performance Buildings Directive (EPBD) in the EU, which are already set up in both countries.
- In China, it is essential to give more administrative power to MOHURD in order to implement new code-systems, to expand its actions and to lower authority levels more effectively; for example, like how the EU codify the EPBD framework by law to apply to all member states.
- Regular code revisions, like what the EU is doing, could ensure that the scheme is in line with the objectives with specific characteristics and needs of the building stock being compatible with the every day practice. For example, implementations of China's five-year plan cycle, like how Germany did with its five-year revision plan, in respect to the EPBD guidelines.
- Specific building-code differentiation, in respect to the performance based approach, between building typologies, for example new construction, commercial and retrofitting is necessary and could react of the tremendous building boom in China. Like Germany fitted its code-system to the specific need to increase the retrofit rate of the aged building stock, in China it could be a middle course, in order to ensure no leaks in the immediate future, like in Germany, which is still working on to eradicate.
- Mandatory labeling systems, like the Energy Performance Certificate (EPC) in the EU and Germany, could help China implement the performance-based guidelines into practice, specific to each typology and its requirements.
- It is necessary to monitor the rate of compliance and fulfillment of the regulation framework in both countries. Germany is already on a good track, enforcing inspections and their consequences through the local government, like penalties payments, building freeze etc., which are legal by national law. In China, there is a high need to enforce sanction of MOHURD and lower authorities, in order to get a real image of the compliance rate, not just by a yearly random inspections like in the present.

- For example, those actions could also be executed by governmental Energy Service Companies (ESCOs), which have to report annually and could establish a centralized database, which would represent the current status of the building stock, as a foundation for a better understanding and guidance for future code revisions by MOHURD.

In order to change the attitude of decision makers to make use of non-mandatory labelling and incentive systems, this work would suggest the following:

- For example, Germany and the EU showed a positive cost premium effect on certified buildings. So in China there is the need to establish easy to understand labeling systems and to train and educate major decision makers in order to change their attitude and make use of the incentives.
- Another approach for China could be to create showcases based on certain labelling standards; like the German Passive House standard (almost 90% reduction of energy, those buildings are third party energy independent). In the 90s, Germany set up an experiment to show people the performance effect and benefits of the Passive House .

To increase the use of financial incentives, the following points has to be ensured to achieve a large and sustainable impact:

- It has to be provided to "everybody", like house owners, buyers and developers like in Germany. Not only to project developers like in China.
- For example, Germanys and the EU showed a positive cost premium effect on certified buildings. So in China there is the need to establish easy to understand labeling systems and to train and educate decision makers in order to change their attitude and make use of the incentives.
- Specific incentive programs, like the KfW program supporting the retrofit of existing buildings in Germany, causing the renovation of 520.000 apartments between 2010 to 2011, is a sign of success. Based on strong monitoring programs as well as the incentive, that investment grants is dependent on the achieved energy efficiency, which is how China could leverage parts of its incentive programs in close future.

In regards to this research, the most powerful combination to succeed the objectives consists of a performance-based national approach, like the EPBD directions, with mandatory certification tools e.g. Energy Performance Certificates (EPCs), codified by law to all participants, and linked financial incentives in order to change decision maker's attitude and to raise the acceptance of energy efficient construction and its benefits.

Monitored by an all-over supervising system for final compliance control, it has further establish an entire building catalogue of the actual condition of the building stock to provide data for future revisions and improvements. Announcing those code updates earlier will enable the industry to have ample time to prepare for the adjustments and would create a significant economic and labor market upturn.

In respect to the fast growing economy and construction in China, there will be the need of conserving the old building stock, like in the European Union. Regarding this fact, besides the points mentioned above, it is necessary to create economic innovative products and services in the energy saving and renovation market to offer attractive time-efficient procedures to private and commercial consumers to retrofit existing buildings. As a result, these improvements will enable an effective facelift of the existing building stock and beside the energy and CO2 emission mitigation; it would also create an economic stimulation of construction and technology sector.

Energy-efficient renovation (EER) for example, has been accepted widely as the best solution for aging residential buildings and the data evaluation and the verification of an EER is although feasible, it is time and cost intensive. A verification tool of a standardized evaluation and simulation method would enhance and rationalize EER projects for existing residential buildings.

The aim would be to attract investors and decision makers to retrofit the aged existing building stock with economic benefits from the EER and even making profit out of the potential energy policy incentives and stimulation of the construction market. In addition, the attitude and behaviour of residential building users should focus on the following: heating, cooling and ventilation as well as using the technical building equipment in an accurate way.

Overall, in times of shortage of resources, methods should be developed in order to lower the energy consumption and CO_2 emissions of these structures.

HYPHOTHESIS

Are there computer-aided tools, which is feasible and economic to get implemented in a political manner, that can change the behaviour of the dcision makers to retrofit the existing building stock?

> *For instance, is a modern software simulation precise and efficient enough to predict the technical and economic feasibility of an energy efficient renovation (EER) project?*

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10.2. List of figures