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Advancing Free Trade
for Asia-Pacific **Prosperity**

APEC Nearly (Net) Zero Energy Building Roadmap

APEC Energy Working Group

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Preface

APEC Ministers set a higher target on reducing energy intensity during the 2011 APEC Economic Leaders' Declaration---To reduce APEC's aggregate energy intensity by 45% from 2005 levels by 2035. And this goal is approximately the same carbon emission reduction goal proposed in the Paris Agreement--to limit the temperature increase to 1.5 degrees Celsius.

According to UNFCCC 2015, carbon emissions during building Life cycle account for 30% of global carbon emissions and this proportion will increase to 50% if building energy consumption continues to grow at its current rates. The promotion of Zero Energy Buildings (ZEBs) has proven to be the most effective measure of reducing energy consumption in building sector.

The project (EWG-15-2016A) had accomplished:

(1) A comparison of energy goals from national and regional levels, together with an introduction of higher building energy saving targets from several international building energy alliances and organizations.

(2) A comprehensive collection of policy priority list for buildings among the economies that covered policies, codes, standards, incentives and subsidies, and the certification.

(3) A thorough and comprehensive technical roadmap was tested out to show the various approaches to NZEB.

We believe that NZEB is the most appropriate way to cut down energy consumption in building sector, and the Z-era has come. This report will show APEC economies those ambitious policies and incentives that have been applied in the five economies and how they work. Meanwhile, this report will also strongly support to strengthen the energy reduction goals between UN and APEC 2035 energy intensity target for the building sector, harmonize the Nearly/Net Zero Energy Roadmap within the APEC region, find a flexible approach to reducing building energy consumption through readily accessible methods to achieve NZEB in all climatic zones, prioritize a list of recommendations for APEC economies to fast track the goal of NZEB.

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Chapter 1 Regional energy goal

As the primary goal to support sustainable economic growth and prosperity in the Asia-Pacific region, APEC keep taking effort in turning policy goals into concrete results and agreements into tangible benefits. Under the theme “Creating new dynamism, fostering a shared future” that proposed at the 2017 CEO Summit at Viet Nam, APEC committed to strengthening cooperation and taking joint actions to foster regional economic linkages and growth for a dynamic, inter-connected and prosperous APEC community and promote an Asia-Pacific partnership for inclusive and sustainable development.

Figure 1-1 Symposium on Priorities for APEC 2017

According to the 2017 Joint Ministerial Statement, the APEC 2017 Priorities will focus on: (I) Promoting sustainable, innovative and inclusive growth; (II) Deepening regional economic integration; (III) Strengthening micro, small and medium-sized enterprises’ (MSMEs) competitiveness and innovation in the digital age; and (IV) Enhancing food security and sustainable agriculture in response to climate change.

As for the point of energy application, reducing aggregate energy intensity, accelerating clean, efficient, and renewable energy deployment, pursuing sustainable and resilient energy development, thus to reducing greenhouse gas emissions are still the important issues that APEC take effort every year.

The APEC region consume approximately 60 percent of world energy demand [1] Buildings consume nearly one third of total energy demand in APEC region. It is fortunate that the appearance of Nearly Zero Energy Building (NZEB) provides a perfect solution on building energy supply.

This report will give a vision of the development of NZEB in APEC region, detailed analysis including five of the world's five largest energy users: Canada, China, Japan, Korea, and the United States.

1.1 APEC's commitment to improving energy efficiency

In 2007, APEC Leaders proposed a regional goal to reduce energy intensity by at least 25 percent by 2030 [2].

APEC Ministers set a higher target on reducing energy intensity during the 2011 APEC Economic Leaders' Declaration---To reduce APEC's aggregate energy intensity by 45% from 2005 levels by 2035 [3].

This aspirational goal was reaffirmed in 2013 Declaration and reiterated in 2014. Declaration:

- To double the share of renewables in the APEC energy mix, including in power generation by 2030, as set out in the 2014 APEC Economic Leaders Declaration [4].
- We reiterate our aspirational goal of reducing APEC's aggregate energy intensity by 45 percent from 2005 levels by 2035 and to rationalize and phase out inefficient fossil fuel subsidies that encourage wasteful consumption while still providing essential energy services [5].

In 2014, the Beijing Declaration introduced an 'aspirational goal of doubling the share of renewables in the APEC energy mix, including in power generation, from 2010 levels by 2030' (APEC 2014).

Figure 1-2 The 11th APEC Energy Ministerial Meeting on 2 September 2014. Beijing, China

1.2 Energy intensity and emission target on Paris Agreement

1.2.1 The Paris Agreement

The Paris Agreement is an agreement within the United Nations Framework Convention on Climate Change (UNFCCC) dealing with greenhouse gas emissions mitigation, adaptation, and finance starting in the year 2020. It was publicized and adopted by consensus in 2015 United Nations Climate Change Conference included the 21th Conference of the Parties (COP 21) in Paris on 12 December 2015 [6].

The Paris Agreement central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives.

1.2.2 The Copenhagen Summit

Before COP 21, the 2009 United Nations Climate Change Conference, commonly known as the Copenhagen Summit, is also well known for the Copenhagen Accord which is according to the Bali Road Map, a framework for climate change mitigation beyond 2012 was to be agreed there [7]. The Copenhagen Accord was drafted by the United States, China, India, Brazil and South Africa on 18 December, and judged a "meaningful agreement" by the United States government. It was "taken note of", but not "adopted", in a debate of all the participating countries the next day, and it was not passed unanimously. The document recognized that climate change is one of the greatest challenges of the present day and that actions should be taken to keep any temperature increases to below 2°C. The document is not legally binding and does not contain any legally binding commitments for reducing CO_2 emissions [8].

1.3 Energy Goal in APEC economies

It is quite different when APEC economies face the challenges on reducing energy consumption and carbon dioxide emissions. This part will show the energy strategy on national level from five largest energy using economies in APEC region: Canada, China, Japan, Korea, and the United States.

1.3.1 Canada

Population and Energy are two important national policies in Canada. According to the statistics and estimations that have been published, the population of Canada will reach 41,517,659 by 2035 and 100% of the population increase will depend on immigrants [9]. For Canada, the rapid increase in CO_2 emissions during the past decades and the continued dependence on fossil fuels and overall demand for energy has been a serious issue for Canadian governments.

Canada maintains the highest energy supply per capita among APEC regions and emissions from the oil and gas sectors increased by 14% in 2005-2015, despite Canada’s low-carbon electricity mix (largely hydro and nuclear) [10]. According to the latest energy statistics, the total primary energy supply in Canada in 2015 is 278.4 Mtoe, and the building sector accounts for 35%-40% of the total consumption.

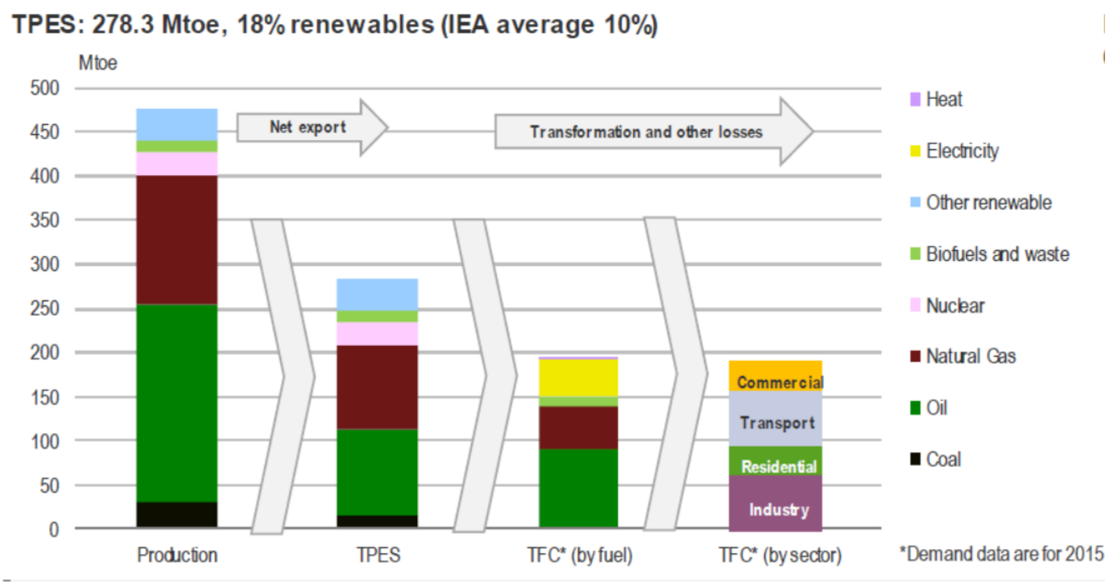


Figure 1-3 Energy supply and demand in Canada in 2016

The federal government of Canada has made tackling climate change a policy priority and committed to **reducing its own emissions to 40% below 2005 levels by 2030 or sooner.**

1.3.1.1 The Vancouver Declaration on Clean Growth and Climate Change

In order to meet or exceed the Canada's 2030 target, the First Ministers issued the Vancouver Declaration on Clean Growth and Climate Change in Vancouver on March 3, 2016 and agreed that a collaborative approach between provincial, territorial, and federal governments is important to reduce GHG emissions and to enable sustainable economic growth.

The Pan-Canadian Framework on Clean Growth and Climate Change (The Pan-Canadian Framework) is a collective plan that built to reduce emissions and improve building resilience to adapt to a changing climate. It is based on the Vancouver Declaration and for the Canada's provincial and federal governments, it is also a commitment to ensuring that the provinces and territories have the flexibility to design their own policies and programs to meet emission-reductions targets.

Federal, provincial, and territorial governments will work together to make sure new actions build on and complement existing plans, policies, programs, and regulations and reflect lessons learned from past experience. New policies will be designed to focus on GHG-emission outcomes and will recognize flexibility for regional differences, including through outcomes-based regulatory equivalency agreements. Indigenous Peoples will be involved in defining and developing policies to support clean energy in their communities.

The Canadian Energy Strategy: As agreed under the Vancouver Declaration and building on the Quebec Summit on Climate Change in 2015, federal, provincial, and territorial energy ministers are collaborating on specific actions through the Canadian Energy Strategy, to contribute to the Pan-Canadian Framework on Clean Growth and Climate Change. Actions include energy conservation and efficiency, clean energy technology and innovation, and deployment of energy to people and global markets.

1.3.1.2 The Energy Efficiency Act

In Canada, buildings account for about 53% of Canada's electricity consumption among which 71% of the buildings are residential buildings, and the remainder are commercial buildings and federal buildings [11]. Most dwellings in Canada are single detached houses (nearly 70%), followed by apartments (20%), single attached houses (10%) and mobile homes. There are four major uses of commercial buildings in Canada: offices (35% of commercial floor space), retail trade (17%), educational service (14%), and health care and social assistance (9%). As for federal buildings, since 89% of the government's emissions come from energy required for buildings (including office space, laboratories and warehouses) compared to 11% from its fleet vehicles.

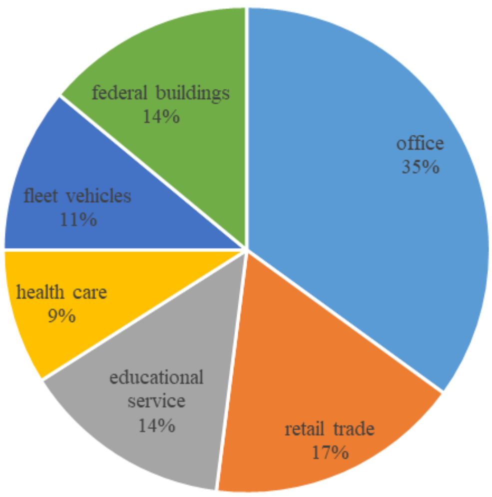


Figure 1-4 Major uses of commercial buildings in Canada

To strengthen its position as responsible energy supplier and user, Canada must take actions to mitigate emissions and energy intensity. The federal government, with the provinces, has put forward stringent energy efficiency and emission standards in buildings, which means a total floor space of 2.2 billion square meters of building needs to decrease the energy consumption. This can continue to develop its resources in a sustainable and cost-effective manner while balancing its economic and sustainability goals.

Federal policies to address GHG emissions are underpinned by several legislative instruments, most notably by the CEPA 1999, which includes authority to regulate GHG emissions and, indirectly, the Energy Efficiency Act (1992) which provides authority to regulate minimum energy efficiency standards for energy-consuming products, product labelling, and collection of data on energy use.

The Energy Efficiency Act authorizes the federal government to establish Minimum Energy Performance Standards (MEPS), set labelling requirements, promote energy efficiency and the use of alternative energy sources, and to collect data for energy-using products that are marketed in Canada.

1.3.2 China

During the nineteenth National Congress of the Communist Party of China (the 19^{th} NCCPC), Chinese President Xi Jinping proposed that it is the historical intersection of the **Two Centenary Goals** from the 19^{th} NCCPC to the 20^{th} NCCPC. During this period, the targets of **building a moderately well-off society in an all-round way by 2035** and **basically achieving socialist modernization by 2050** are the most important historical mission and national strategy for Chinese governments.

As the world's largest energy consumer in 2014 (23% of total global energy consumption), largest energy producer (19% of total global energy supply), the largest oil importers and carbon dioxide emitters, China is at the center of global energy affairs.

The concept and practice of global energy governance in China are influenced and shaped by the changing domestic and international development environment.

In November 2014, Chinese President Xi Jinping announced that **China vowed to**

put a peak on its growing carbon dioxide emissions by the year 2030 with non-fossil fuel sources making 20 percent of energy sources by then. The pledge has become part of each country's national commitments for the 2015 Paris Agreement, which was adopted during the United Nations' climate conference in December 2015.

Following China's commitment to peak CO_2 emissions in 2030 at the 21st Convention of Parties to the UNFCCC (COP 21), the government launched a long-term Strategy of Energy Production and Consumption Revolution (2016-2030) in December 2016 [12]. As a guiding document, this Strategy is seen as an ambitious commitment to support China's Nationally Determined Contribution in the long-run. It includes comprehensive policies and measures to:

- Reform the demand side: 1) controlling total energy consumption; 2) structural change on industrial transformation (to support the advanced industries and the service sector); 3) further improving energy conservation and emission reduction; 4) promoting urban and rural electrification; and 5) behavior and awareness change.
- Reform the supply side: 1) optimising the production and utilisation of coal; 2) enabling renewable energy to match the majority of demand growth; 3) promoting supply-side management; and 4) developing smart energy system.
- Reform the energy market: 1) establishing a market-based energy price mechanism; 2) transformation towards a more inclusive, efficient and competitive energy market; 3) innovate administration and reducing government intervention; and 4) optimizing the legal system governing energy.
- Innovation of energy technology: 1) scaling-up the deployment of energy efficient technologies; 2) promoting R&D of technologies related to energy development and use; 3) developing smart energy system technologies; and 4) improving research capacity for frontier technologies.
- Strengthen international energy cooperation and improve domestic energy security.

In summary, the Strategy outlines 13 key measures covering behavior change, "Double Control", clean energy, energy efficiency, and technological innovation, digitalization of energy networks, standards, and international collaboration.

The Strategy also sets up binding targets to complement China's existing policies for different timeframes. For example, between 2016 to 2020 (the 13th Five-Year Plan period), China will improve energy efficiency by a minimum of 15% and to cap total energy consumption to 5 billion tons of coal equivalent (TCE). Between 2020 and 2030, China will cap total energy consumption to less than 6 billion TCE, meeting the growing energy demand through renewable energy and having non-fossil fuels account for 20% of total energy consumption by 2030 and over 50% by 2050. In addition, it calls for the further reduction of the total energy consumption share of coal. As a result, the estimated investment demand in energy conservation and renewable energy will amount to USD 10.3 trillion between 2015 and 2030.

With the continuous improvement of domestic energy supply, China's per capita electricity consumption has exceeded the world average level. The energy consumption gap between urban and rural residents has been significantly reduced. According to the statistics of the U.S. Energy Information Administration, from 1998 to 2012, the energy consumption of buildings in China grew by about 7.7% per year, much faster than China's average annual population increase, which was less than 1% per year. This consumption growth was driven by growing incomes and modernization that significantly increased the use of electricity and other forms of energy.

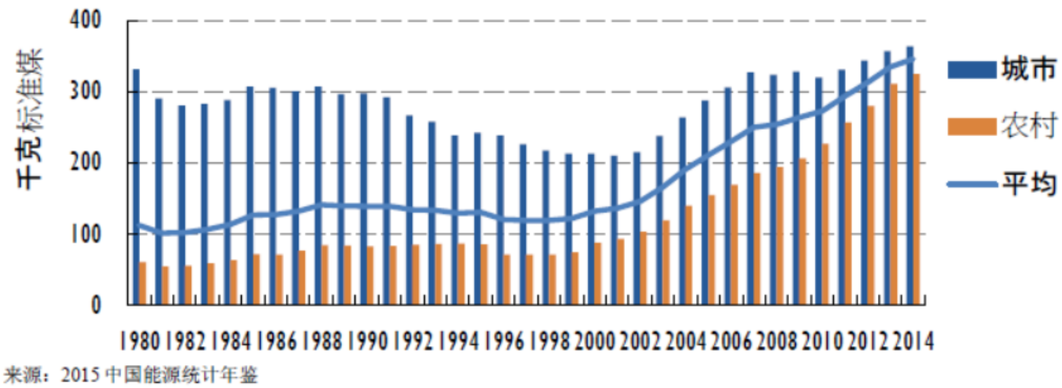


Figure 1-5 Per capita energy consumption in China

The MOHURD issued "*The 13th FYP Building Energy Conservation and Green Building Development Subject Plan*" (The "*Plan*") on March 31th, 2017, which aims at promoting ultra-low-energy building and nearly zero-energy building---- **By 2020, over 10 million ㎡ of ultra-low-energy buildings and nearly zero-energy buildings will be constructed** [13].

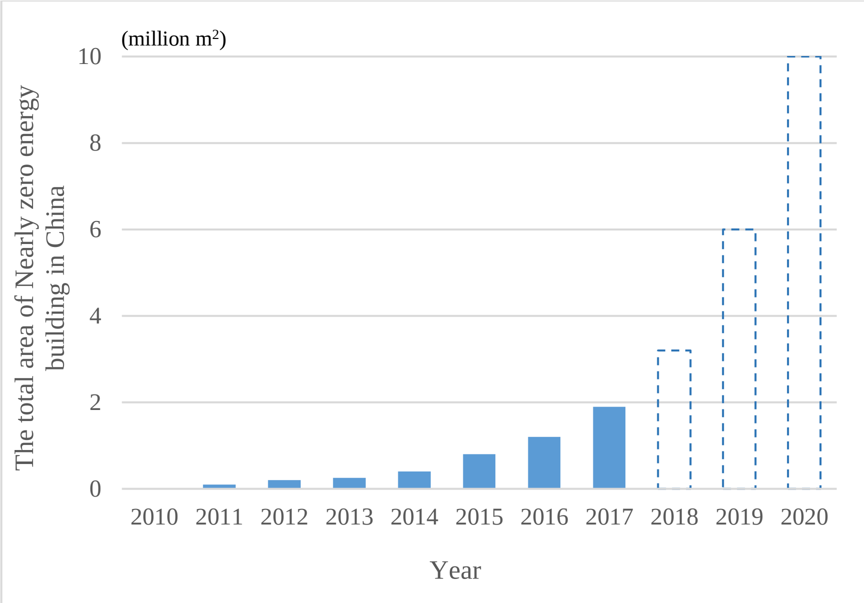


Figure 1-6 The development of NZEB in China by 2020

1.3.3 Japan

As the major player in the world of energy, Japan is one of the largest energy consumers and importers. It is also a recognized leader in energy technology development and a major exporter in that sector. Security of supply has traditionally been critical to Japan, as it relies on imports for practically all of its fossil fuel supply.

At the 15th Conference of the Parties (COP15) in 2009, **Japan had pledged to reduce its greenhouse gas (GHG) emissions by 25% from 1990 to 2020.** This ambitious pledge largely relied on plans to increase nuclear power's share in electricity supply from 30% to 50%. After March 2011, however, the economy's entire nuclear power capacity was gradually shut down in the aftermath of the Fukushima Daiichi nuclear accident and came to a complete halt in 2013 and this left a gap of 30% in electricity supply. This made Japan start developing new energy strategy and plans to 2030 and beyond.

In April 2014, the Ministry of Economy, Trade and Industry (METI) prepared the 2015 "Long-Term Energy Supply and Demand Outlook" to 2030 which was adopted in July 2015. The 2015 Outlook was prepared with climate change objectives in mind.

A key part of the Outlook is the electricity supply mix for 2030, which projects declines in the share for natural gas, coal and oil, a comeback to nuclear energy and strong increases in renewable energy.

After the adoption of the 2015 Outlook, Japan announced its intended nationally determined contribution (INDC) for COP21 to reduce GHG emissions by 26% from 2013 to 2030. In May 2016, it adopted the Plan for Global Warming Countermeasures. The plan is based on the INDC and the **Paris Agreement by which Japan pledges to head towards cutting emissions by 80% by 2050 under the condition that this is compatible with economic growth.**

Japan's total final consumption (TFC) amounted to 296 Mtoe in 2015. TFC represented around 67% of TPES in 2014, with the remainder used in power generation (including losses) and other energy industries. One third of TFC is in building sector [2].

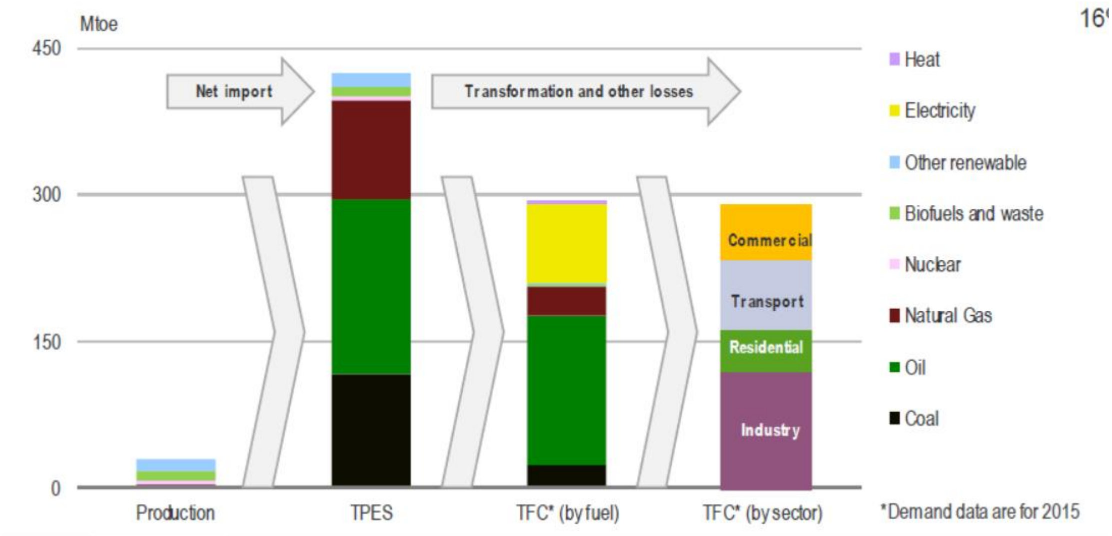


Figure 1-7 Annual total energy supply and demand in Japan in 2015

By FY2030, energy efficiency and conservation are expected to reduce energy demand by 13% (or 50.3 billion litres of crude oil-equivalent) to 326 billion litres compared to the baseline (376 billion litres) assuming economic growth at 1.7% per year from FY2013 to FY2030. This translates into a 10% reduction in final energy consumption from FY2013 [2].

In the 2014 SEP, the government set a target of net zero-energy consumption for new public buildings by 2020 and net zero-energy on average for all new buildings by

2030. With regard to houses, it aims to achieve net zero energy consumption for standard new houses by 2020 and for all new houses by 2030. These targets are included in the energy demand target for 2030 laid out in the 2015 Long-term Energy Supply and Demand Outlook [14].

IEA gives recommendations to Japan according to Japan's energy efficiency progress on the G8 Summit by the Energy Efficiency Progress Report. In the Report, the challenges and areas for improving building energy efficiency are put forward:

Despite being an international leader in energy efficiency policy, Japan can make improvements to energy efficiency in several areas.

Mandatory building requirements for energy efficiency should be further strengthened to include all types of residential, commercial and public-use buildings regardless of the size of the buildings. Further action should be taken to promote ultra-low energy and zero energy buildings.

So the vision for realizing ZEB reached a consensus on that summit----**Realize ZEB for all newly built buildings by 2030.**

To achieve this goal, a series of technical measures were raised which include (Figure 1-8):

- Strict enforcement of energy conservation standards
- Drastic reinforcement of tax incentives
- Drastic enhancement of support on budget
- Development of labeling system for energy conservation

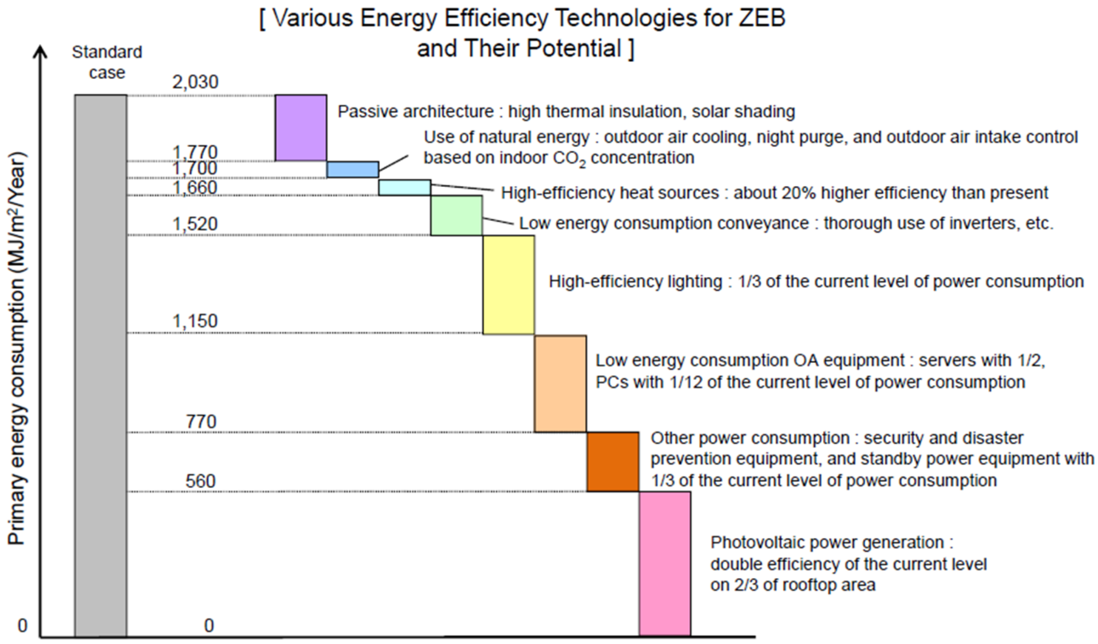


Figure 1-8 technical measures to achieve ZEB

1.3.4 Korea

Korea, the world's thirteenth-largest economy and the seventh-largest exporter, is an energy-intensive nation. According to the statistics for Korea's energy system in 2015 by IEA, the total final consumption (TFC) amounted to 173 Mtoe which represented around 61% of TPES. One third of TFC is in building sector.

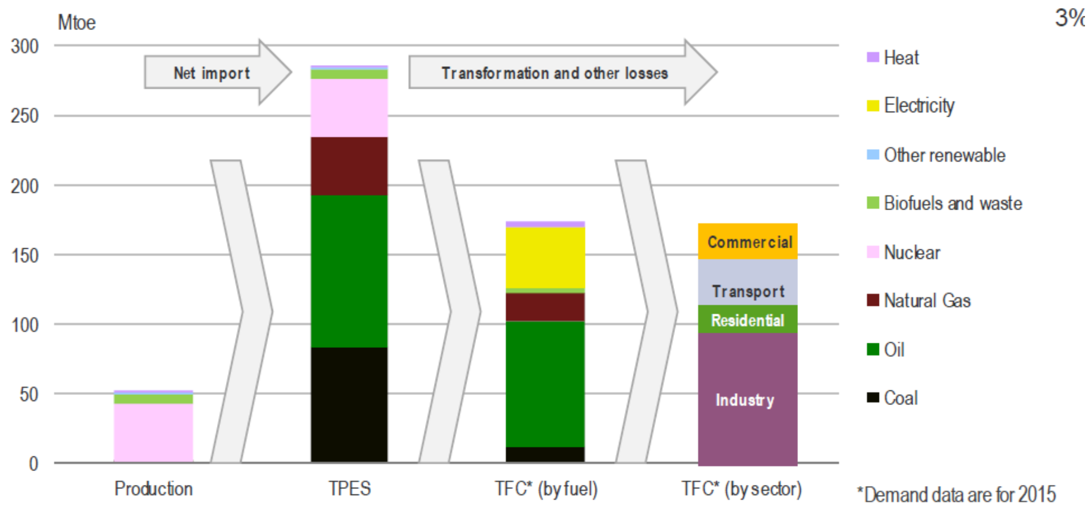


Figure1-9 Annual total energy supply and demand in Korea in 2015[14]

Since 2008 the Korean government has established the National Energy Master Plan every five years covering next 20 years. In January 2014 the Korean government announced the 2nd National Energy Master Plan up to 2035. The plan outlines future energy policy direction, such as the realization of low-carbon society, and calls for energy security increase, rational use of energy, and environment protection. The government will actively support the development and deployment of non-fossil energy such as new and renewable energy and nuclear, along with energy demand-side management. Climate change is also viewed as an urgent issue, and the government will facilitate the carbon market and promote the public energy saving activities. **The plan sets various energy targets: to reduce final energy consumption by 13% below BAU level by 2035, and to achieve the share of 11% of renewable energy in total energy consumption by 2035.**

This goal can be applied to the four main sectors: industry, building, transport and public, building takes 19.6% in total energy demand. The government set goals for codes reinforce: By 2025, all new buildings will achieve zero energy building [15].

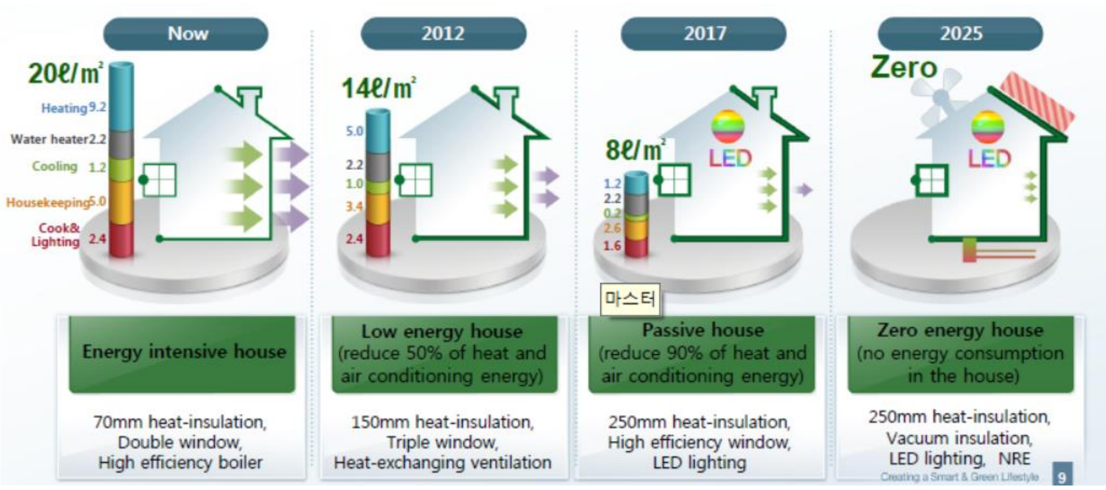


Figure 1-10 Technical rules to develop ZEB

According to this plan, 10,000 m^2 of office building will be under implementation of the zero energy goal.

1.3.5 The United States

According to the statistics from IEA, the total final consumption (TFC) amounted to 1500 Mtoe which represented around 69.4% of TPES. One third of TFC is in building sector [16].

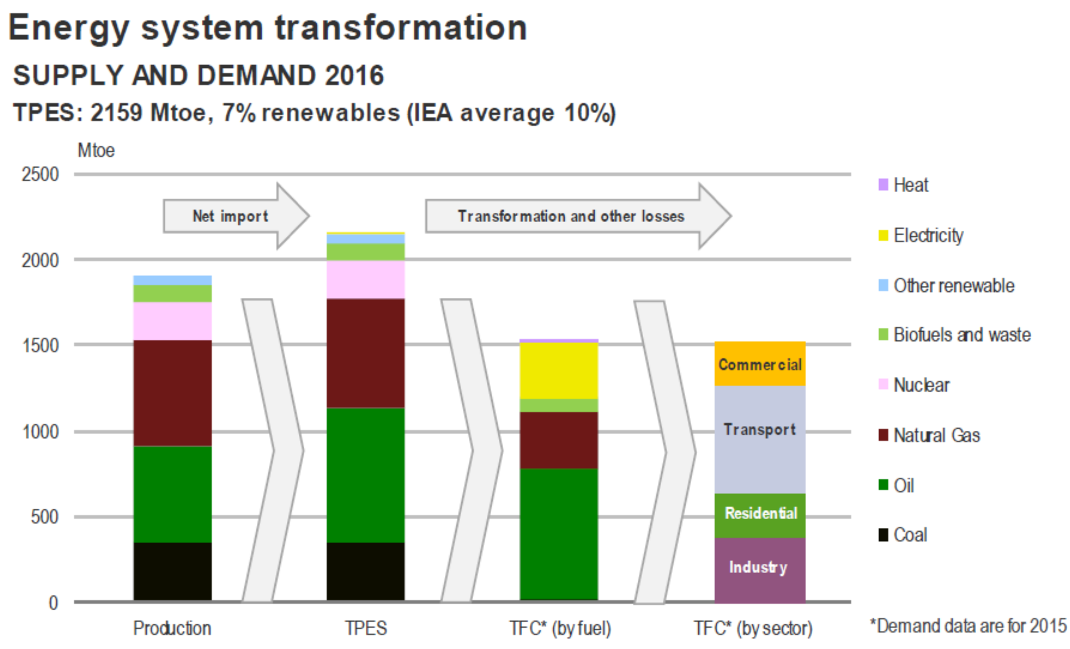


Figure 1-11 Annual total energy supply and demand in the United States in 2015

In 2009, at the negotiations of the United Nations Framework Convention on Climate Change (UNFCCC) in Copenhagen, the President **committed the United States to the goal of reducing GHG emissions in the range of 17% from 2005 levels by 2020 in conformity with any legislation** [16].

The President's Blueprint for a Secure Energy Future of 2011 provided a clear signal to policy makers and industry stakeholders, as well as to the public, as to the medium-term direction of federal energy policy: doubling of electricity generation from wind, solar and geothermal sources by 2020, halving net oil imports by the end of the decade and doubling energy productivity by 2030 as well as providing international leadership in clean energy. The "All-of-the-Above" strategy, announced in 2012, established three clear goals: support for economic growth and job creation, enhanced energy security, and deployment of low-carbon energy technologies, all supported by a series of defined policy actions.

1.4 Pursuit of higher building energy saving target

1.4.1 World Green Building Council-From thousand to billion

The World Green Building Council (WorldGBC) is a global network of Green Building Councils which actively respond to COP 21. World leaders reached a major agreement to "combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future”. [17]

The WorldGBC infographic highlights key information relating to the global project (Figure 1-12), Advancing Net Zero, during which two ambitious goals are proposed:

All new buildings must operate at net zero carbon from 2030

Net zero carbon buildings must become standard business practice as soon as possible, so we build right from the start; avoid the need for future major retrofits; and prevent the lock-in of carbon emitting systems for decades to come.

100% of buildings must operate at net zero carbon by 2050

Existing buildings require not only an acceleration of current renovation rates, but these renovations must be completed to a net zero carbon standard so that all buildings are net zero carbon in operation by 2050.

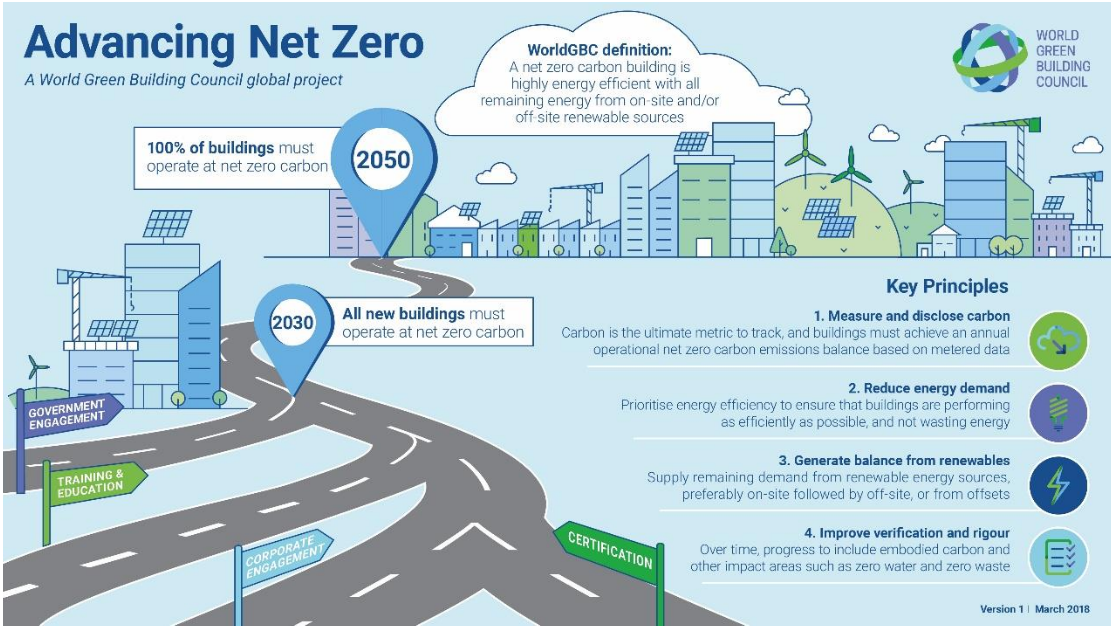


Figure 1-12 Advancing Net Zero Program

The WorldGBC published its report ***From thousand to Billion*** in May 2017 to explain the way to realize the 2030 Goal and 2050 Goal --coordinated action of Businesses, Government and NGOs. The WorldGBC has been busy responding to this call to action, developing mechanisms and initiatives to facilitate mass market transformation, and lead the way, inspiring the business and government communities to follow.

1.4.2 Architecture 2030 Challenge

To accomplish the goal of keeping global average temperature below 2°C above pre-industrial level, Architecture 2030 issued The 2030 Challenge asking the global architecture and building community to adopt the following targets [18]:

All new buildings, developments and major renovations shall be designed to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 70% below the regional (or economy) average/median for that building type.

At a minimum, an equal amount of existing building area shall be renovated annually to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 70% of the regional (or economy) average/median for that building type.

The fossil fuel reduction standard for all new buildings and major renovations shall be increased to:

- 80% in 2020
- 90% in 2025
- Carbon-neutral in 2030 (using no fossil fuel GHG emitting energy to operate).

These targets may be accomplished by implementing innovative sustainable design strategies, generating on-site renewable power and/or purchasing (20% maximum) renewable energy.

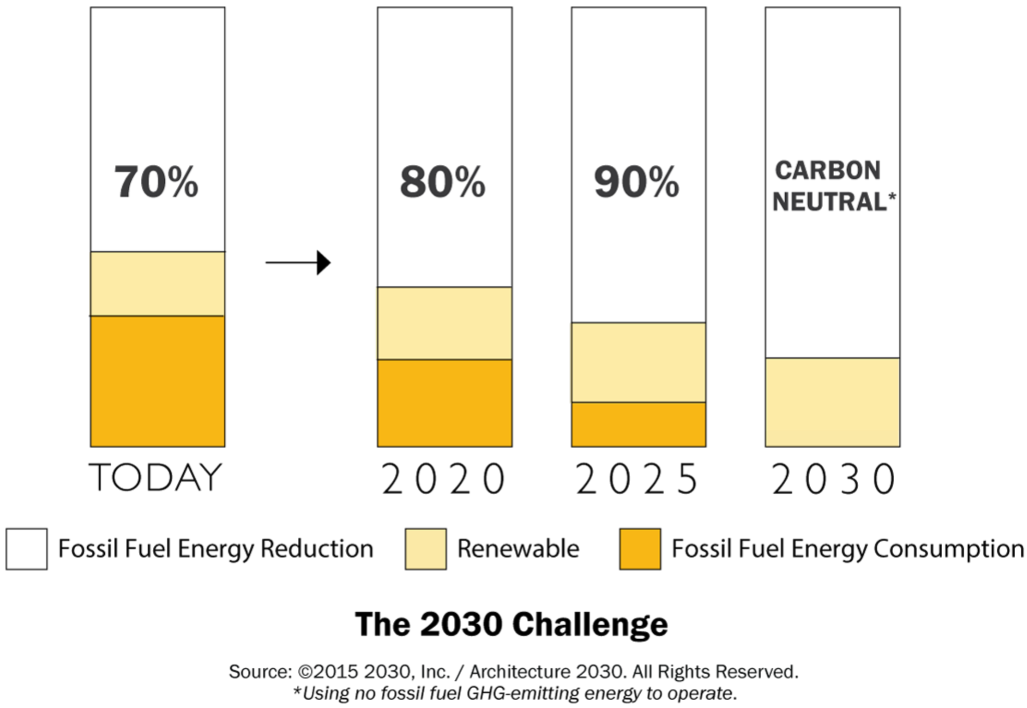


Figure 1-13 Architecture 2030 Challenge

To support the 2030 Challenge, the American Institute of Architect's 2030 Commitment—a national framework with a standardized reporting format—helps design firms meet the 2030 Challenge and provides a structure for tracking progress. Over 525 Architecture/Engineering/Planning firms have adopted the 2030 Commitment and these firms have been tracking and reporting projects since 2010, with over 300 million m^2 of project work in 93 countries reported in 2017 alone.

1.4.3 China Passive Building Alliance 30-30-30 Goal

China Passive Building Alliance (CPBA) is a non- profit organization aiming at driving better energy performance in buildings with proactive vision and reliable cooperation. CPBA works collaboratively with industry market players--universities, research institutions, utilities, energy efficiency advocates, and building professionals--to promote passive building, nearly zero energy building and zero energy building in China.

As the close partner and biggest support of MOHURD, CPBA proposed its 30-30-30 Goal to respond to the 13th FYP NZEB development goal: By the year 2030, 30% of the new building will be NZEB, and 30% of the existing building will be renovated to achieve NZEB.

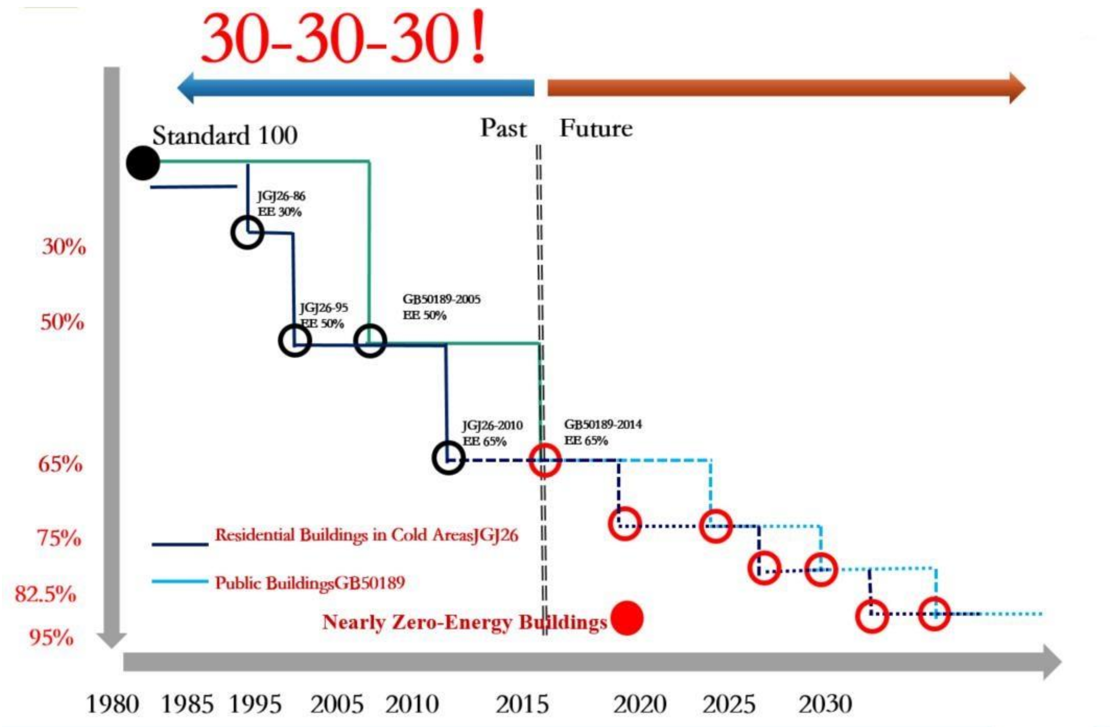


Figure 1-14 CPBA 30-30-30 goal

1.4.4 SHASE Target to realize ZEB

The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan (SHASE) is a major organization for heating, air-conditioning, and sanitary engineering in Japan which is also an active impellor of ZEB. SHASE proposed its ZEB target in 2015:

ZEB will be realized in 2 phases; “the Promotion stage” for becoming ZEB in specific buildings in early stage and “the Dissemination Stage” for expanding ZEB in all other buildings [19].

(1) Realization in specific buildings (the Promotion stage)

Completion of the promotion stage is targeted by 2020 (within five years).

(2) Expansion to the other buildings (the Dissemination Stage)

To meet the requirements of METI (Ministry of Economy, Trade and Industry), MLIT (Ministry of Land, Infrastructure and Tourism) and MOE (Ministry of Environment) Roadmap, expansion to the other buildings is targeted by 2030.

1.5 APEC energy intensity goal update suggestion

Past policies and programs have improved energy efficiency in the economy, and new policies and programs will result in even more efficient use of energy, contributing to a cleaner economy.

Chapter 2 Policies Priorities for Buildings

2.1 Canada

Homes and commercial buildings both used about 31 Mtoe of final energy in 2005 (IEA, 2007). The top three end uses in dwellings are space heating (60% of the residential energy use in 2005), water heating (18%) and appliance usage (14%) (OEE, 2007). Space heating (51%), auxiliary equipment (14%) and lighting (9%) are the three main end uses in commercial buildings (OEE, 2007) [12]

2.1.1 Mid-Long term Building Energy intensity Target

The policies and measures to reduce emissions are in place at both the federal and provincial levels in Canada.

With the help of federal programmes, like the ecoENERGY Efficiency Initiative, the federal government has worked together with the provinces and territories as well as with all industry stakeholders and non-governmental organizations (NGOs) on the preparation of harmonized approaches to avoid diverging requirements across Canada. For instance in the buildings sector, the National Energy Code for Buildings was adopted as a federal model code, which provinces and territories can adopt and adapt to their local requirements.

2.1.2 Codes

National Energy Code of Canada for Buildings 2015

The new version of the National Energy Code of Canada for Buildings (NECB 2015) is available from the Canadian Codes Centre as of December 18, 2015. NECB 2015 contains more than 90 new changes that will help to ensure a high energy efficiency level in new Canadian buildings, including [20]:

- New thermal requirements for semi-heated buildings
- A performance level for air barrier assemblies of opaque building assemblies
- Updated maximum allowable lighting power densities (LPDs), which are harmonized with those of ASHRAE 90.1-2013
- Updated interior lighting control requirements

- Updated piping and duct insulation requirements
- New prescriptive requirements based on AHSRAE 90.1-2013 for hydronic pump systems and heat rejection equipment such as cooling towers
- Demand control ventilation for parking garages
- New prescriptive requirements for gas-fired outdoor packaged units (such as rooftop units)
- Updated performance requirements in the mechanical and service water heating system equipment tables, which align with the federal Equipment Efficiency Regulations
- Reduced hot water discharge rate for showers and lavatories

Work is already well underway to continue finding more opportunities to improve the performance level of the NECB as the market moves closer and closer toward Net Zero Energy buildings [21].

2.1.3 Incentives and subsidies

The federal government offers support to federally owned buildings to help reduce their energy footprint. Since 1991, the Federal Building Initiative has provided knowledge, training, expertise, and assistance to plan and implement energy-saving projects. The programme provides support to plan for an energy performance contract. The government is saving CAD 59 million annually in energy costs thanks to these projects. Some CAD 420 million in costs has been financed by the companies, instead of the government.

A Net Zero Energy Housing Council was established in 2014 to guide the Canadian Home Builders' Association (CHBA)'s efforts in high-performance housing. The council initiated the Labelling Program to distinguish and recognize Net Zero and Net Zero Ready Homes and the builders/renovators [22].

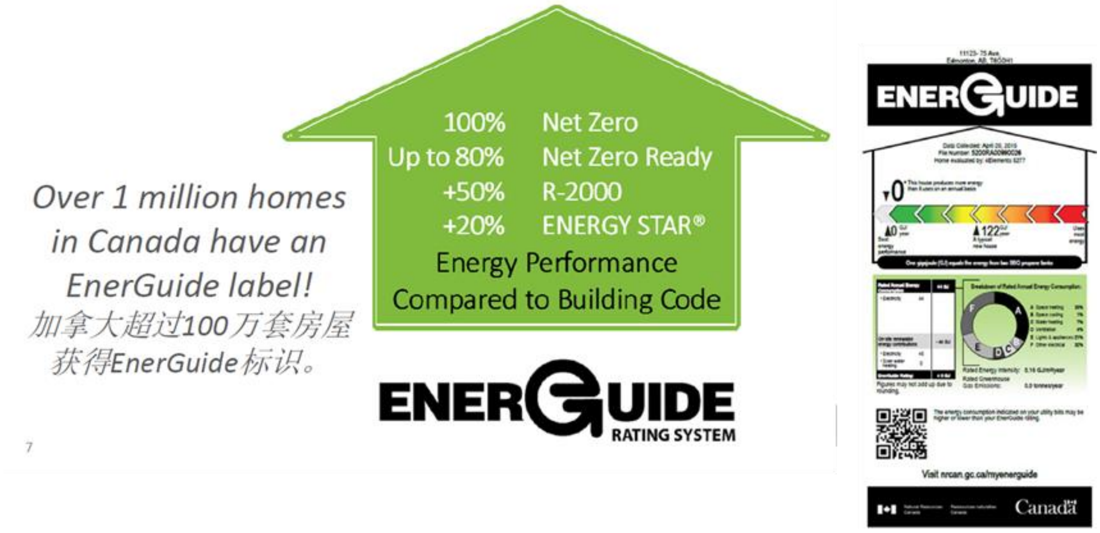


Figure 2-1 Labelling Program in Canada

Supporting the CHBA Strategic Priority to advance innovation in our industry, the goal is to create a market advantage for CHBA members.

The Canadian Mortgage and Housing Corporation offers reduced mortgage loan insurance premiums for home-buyers who purchase energy-efficient homes or make energy efficiency upgrades.

2.1.4 Certifications

R-2000 Homes

The R-2000 Net Zero Energy Pilot aimed to recognize builders and homes reaching net zero energy performance in Canada. The Pilot also provided the opportunity to rate net zero energy houses using Natural Resources Canada's (NRCan) EnerGuide Rating System (ERS) as well as to label them under the R 2000 Standard, which was the basis for the Pilot.

The R-2000 Standard presents the criteria that a new house must meet to be eligible for R-2000 certification. The technical requirements of the R-2000 Standard include measures for the efficient use of energy, improved indoor air quality and better environmental responsibility in the construction and operation of a house.

The goal of the R-2000 Standard is to improve the energy efficiency of new houses without sacrificing either the interior or exterior environments. These technical requirements include both the performance goals and prescriptive measures that a house must meet to become eligible for R-2000 certification. The requirements are intended to give the builder flexibility in the selection of construction techniques, building products, mechanical equipment, lighting and appliances. The R-2000 Standard is periodically updated to ensure that R-2000 houses represent the leading edge of cost-effective housing technology [23].

Energy Star and EnerGuide labels

The ENERGY STAR and the EnerGuide labels are the national labels for key consumer items—houses, light-duty vehicles, and a number of energy-using products. The ENERGY STAR marking indicates that the product or appliance is in the top 15% to 30% of its class for energy performance, making it easier for consumers to choose highly efficient products. Products that display the symbol have been tested according to prescribed procedures and have been certified to meet or exceed higher energy efficiency levels without compromising performance. About 1,000 major manufacturers and retailers of energy-efficient products, utilities and energy retailers promote the label in over 70 product categories.

R&D Programs

Smart Net-zero Energy Buildings strategic Research Network (SNEBRN) brings together 29 Canadian researchers from 15 universities to develop smart net-zero energy homes and buildings of the future. The Network was awarded $5M over 5 years (2011-016) from Natural Sciences and Engineering Research Council (NSERC) to perform research that would facilitate widespread adoption of net-zero energy buildings (NZEB) design and operation concepts suited to Canadian climatic conditions and construction practices by 2030, in key regions of Canada. Concordia University, the project proponent, and its network of university partners were awarded $1M from ecoEII to conduct research on selected promising technologies that would enable net-zero energy homes and buildings [24].

The SNEBRN has been tentatively approved for a third strategic research network ($7.5 M research program for 2019-24) with the title "NSERC Smart Solar Buildings and Communities (SSBC) Strategic Network" with close to 30 researchers from 15 Canadian Universities. The SSBC Network, in addition to the net-zero energy goals emphasizes resilience, particularly at the community level, with integration of EVs as well. Currently it is planning in collaboration with the Canadian

Academy of Engineering a workshop to provide input to policies, standards, and development of incentive measures for Canada to achieve its goals for 80% reductions in GHG emissions by 2050 while ensuring resilience.

2.2 China

Population control, efficient utilization of limited resources and environmental protection have been taken as fundamental policies by the Chinese government to safeguard sustainable social economic development. The strategic importance of energy conservation in China can be summarized as follows:

1) Effectively relieve future energy demand and supply pressure
2) Relieve regional and global environmental pressure
3) Increase economic competitiveness
4) Reducing dependence on international energy market

2.2.1 Policies----short term goal（2016-2020）

China's building energy conservation work started in the late 1980s, during the recent three decades, energy consumption in China has been increasing rapidly due to economic growth and development. With speeding modernization and urbanization, building energy consumption has steadily increased in China.

According to the statistical data, the share of building energy consumption in total energy consumption in China rose from 10% in 1978 to 30% and continues to maintain growth.

Compared with other industries, the sector of building will play a key role in energy consumption and become a prime objective for energy efficiency. Since 2006, the central government issues a series of measures about BEE to respond the challenge of rapid increasing building energy consumption owing to the increasing demand of more new buildings and household appliances

2.2.1.1 China 13th FYP Update--- China State Council Work Plan

On 6 January, 2017, China State Council issued the "*13th Five Year Comprehensive Work Plan for Energy Conservation and Emission Reduction*" (the "Work Plan") for the 2016-2020 period which sets forth implementation guidelines for energy conservation and emissions reductions. The plan listed 11 detailed measures to push forward China's energy-saving and emission-reduction work among which **strengthen building energy conservation** was highly noted.

The leading advanced standards for building energy conservation will be implemented and ultra-low energy consumption building/ nearly zero energy building demonstration pilots will be launched.

2.2.1.2 China 13th FYP Update---MOHURD

To guide and promote the sustainable development of the construction industry in the 13th five-year plan period, Ministry of Housing and Urban-Rural Development (MOHURD) issued "*The outline of the 13th FYP for housing and urban-rural development*" (the "*Outline*") on May 3rd, 2017. According to the Outline, a number of ultra-low energy building and nearly zero energy building demonstration projects will be constructed in different climate zones as soon as possible, thus to give full play to the leading role of building energy efficiency improvement benchmarks, and meanwhile help promoting the development of ultra-low energy communities.

2.2.1.3 China 13th FYP Update--- MOHURD

The MOHURD issued "*The 13th FYP Building Energy Conservation and Green Building Development Subject Plan*" (The "*Plan*") on March 31th, 2017, which aims to build a high energy efficient and low-carbon ecological building energy system, thus to promote supply-side structural reform in urban and rural areas. According to the Plan, the local government should set up benchmarks in different climate zones, Actively carry out the construction of pilot ultra-low energy buildings and nearly zero energy building demonstrations, and promote the contiguous construction of ultra-low energy buildings in the campus where conditions permit.

2.2.1.4 Local government set nearly zero energy building development goals

Beijing：Civil Building Energy Efficiency Plan during the 13th FYP Period

No less than 300,000 ㎡ of ultra-low-energy demonstration buildings will be constructed in 5 years, among which, at least 200,000 ㎡ will be supported by government investment. Promote large-scale development of ultra-low-energy buildings in ecological demonstration zones like Beijing's new sub-centers.

Shandong：Special Fund for Building Energy Efficiency and Green Buildings

Provide financial incentives for passive ultra-low-energy buildings and nearly zero energy building based on the incremental cost. The minimum requirement of floor area for residential and public buildings are 5000 ㎡ and 3000 ㎡ respectively.

2.2.2 Codes and standards

China adopted building energy standards in stages, starting with an energy design standard for residential buildings in the Heating Zone in north China in 1986, and then standards for residential buildings in the Hot-Summer Cold-Winter Region in central China in 2001 and the Hot-Summer Warm-Winter Region in south China in 2003. A national energy efficient design standard for public buildings (similar to commercial buildings) was adopted in 2004 and revised in 2014. Preceding these national or regional standards, there have been also local standards in major cities, such as Beijing, Shanghai, Wuhan, and Chongqing.

From an institutional point of view, China has benefit of a centralized Ministry of Housing and Urban-Rural Development (MOHURD) responsible for regulating a building industry that over the past decade has built roughly half of the new construction of the entire world. Under the MOHURD, there is a network of Construction Commissions in the major cities and provinces to oversee building construction, including the granting of building permits and enforcement of building codes, as well as a parallel network of building research institutes to provide technical expertise and support to the MOHURD and the building industry. Within the MOHURD, building energy standards fall under the jurisdiction of the Department of Standards and Norms. However, the technical development of building energy standards is the responsibility of the Department of Science and Technology, in collaboration with building research institutes, universities, and industry representatives. For example, for the current residential and public building standards, Code Compilation Committees were organized under the leadership of the China Academy of Building Research. Local governments can choose to either comply with the national codes or adopt more stringent local codes.

The Chinese government has prioritized promoting ultra-low energy building and nearly zero energy building during the 13th FYP period. The corresponding standards have been gradually completed.

2.2.2.1 The "Passive Ultra-low Energy Green Building Technical Guidance"

In order to implement the strategic deployment of the Party Central Committee to promote ecological civilization and new urbanization and to further improve the development level of building energy efficiency, the MOHURD issued the Passive Ultra-low Energy Green Building Technical Guidance (For residential building) in November 2015 which was considered as China's first Ultra-low energy building technical guidance.

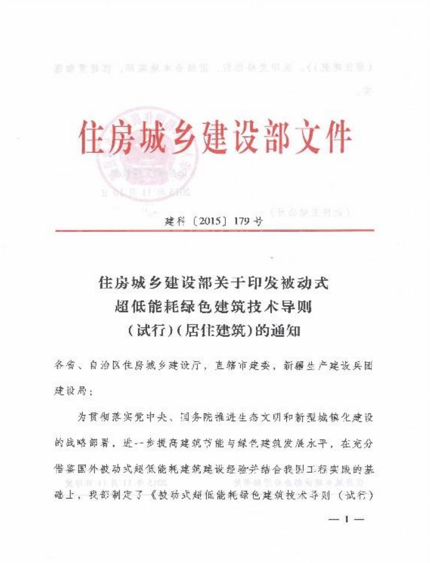
The main performance criteria of Chinese passive nearly zero energy buildings are listed in Table 2-1[25].

Table 2-1 Main performance criteria of Chinese passive nearly zero energy buildings

Annual Heating and cooling demand (kWh/ m^2.a)	**Climate zones**	Severe cold	cold	Hot summer and cold winter	Hot summer and warm winter	Temperature
	Heating demand	≤18	≤15	≤5		
	Cooling demand	≤3.5+2.0×WDH20 +2.2×DDH28				
The primary energy consumption for cooling, heating and lighting	≤60 kWh/m^2.a/(7.4kgce/m^2.a)					
Air tightness	N_{50}≤0.6					

This can be treated as the milestone for China's NZEB development. This was also the first time that China established the Ultra-low energy building definition officially which can be considered as the first step to NZEB.

The Ultra-low energy consumption building is a combination of higher thermal insulation performance, air tightness, and high efficient air heat recovery technology, which can adapt to the climate characteristics and natural conditions, thus can reduce the building heating and cooling requirements, make full use of renewable energy and provide a comfortable indoor environment at maximum extent.



住房城乡建设部文件

建科〔2015〕179 号

住房城乡建设部关于印发被动式
超低能耗绿色建筑技术导则
（试行）（居住建筑）的通知

各省、自治区住房城乡建设厅，直辖市建委，新疆生产建设兵团建设局：

为贯彻落实党中央、国务院推进生态文明和新型城镇化建设的战略部署，进一步提高建筑节能与绿色建筑发展水平，在充分借鉴国外被动式超低能耗建筑建设经验并结合我国工程实践的基础上，我部制定了《被动式超低能耗绿色建筑技术导则（试行）

— 1 —

（居住建筑）》。现印发给你们，请结合本地实际，抓好贯彻落实。

中华人民共和国住房和城乡建设部

2015 年 11 月 10 日

（此件主动公开）

住房城乡建设部办公厅秘书处　　2015 年 11 月 11 日印发

— 2 —

Figure 2-2 Passive ultra-low energy consumption Green building technical guidance

2.2.2.2 The “Nearly Zero Energy Building Technical Standard”

The kick-off meeting of Nearly Zero Energy Building Technical Standard (Standard for short) was launched in October, 2016. The Standard will be published and

implemented in 2019 which will be the first official NZEB standard in China.

Figure 2-3 The kick-off meeting of Nearly Zero Energy Building Technical Standard

The drafting group of the standard was compiled by 50 agencies that covers area of design, construction, operation and facilities. The Standard will be published in Dec 2018 and planned to be mandatory in 2035:

- Both residential buildings and public buildings
- Cover all climate zones
- 70% more energy efficiency with existing standard as reference

In October 2015, with the support of the China Exploration & Design Association Architecture Branch (CEDAAB) and Architecture 2030, 24 international firms and 28 Chinese Local Design Institutes (LDIs) signed the China Accord, a voluntarily pledge to plan and design to carbon neutral or near carbon neutral standards. CEDAAB's newly-formed Zero Carbon Green Building Design Committee is committed to pursuing a professional training program for the architecture and planning community in China on Zero Net Carbon (ZNC) principles, strategies, and applications. In late October 2016, a historic two-day forum and workshop event Towards a Zero Carbon Built Environment was held in Wuhan, China, and established ZNC as a necessary and achievable goal for buildings and developments.

2.2.3 Incentives and subsidies

The Beijing temporary management of incentive subsidy on ultra-low energy building demonstration projects.

Table 2-2 Incentives and subsidies at provincial and municipal governments

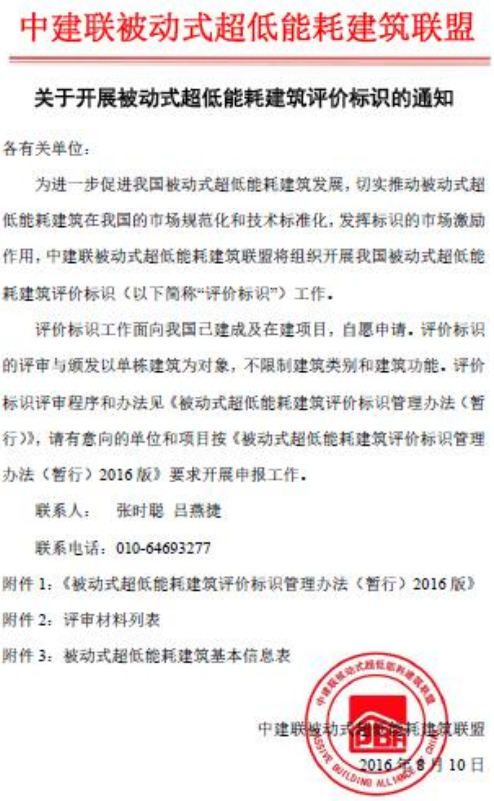
Province	Incentives and subsidy	Subsidy object
Beijing	1000 RMB/m^2, no more than 30 million RMB in single project	Residential or public buildings that certified before October 2017
	800 RMB/m^2, no more than 25	Residential or public buildings

	million RMB in single project	that certified during October 2017~ October 2018
	600 RMB/m^2, no more than 20 million RMB in single project	Residential or public buildings that certified after October 2018
Tianjin	100 RMB/m^2, no more than 3 million RMB in single project	Projects that get certification
Shandong	80% of the total incremental cost	Building scale no less than 5000 m^2 (for residential buildings) and no less than 3000 m^2 (for public buildings)
Hebei	100 RMB/m^2, no more than 3 million RMB in single project	

2.2.4 Certification

The Passive Ultra-low energy building certification

According to the requirement of Passive Building Guideline of MOHURD. The first 15 project get certified in 2016, till now, there are 34 projects that have get certified in 2016 and 2017.



中建联被动式超低能耗建筑联盟

关于开展被动式超低能耗建筑评价标识的通知

各有关单位：

为进一步促进我国被动式超低能耗建筑发展，切实推动被动式超低能耗建筑在我国的市场规范化和技术标准化，发挥标识的市场激励作用，中建联被动式超低能耗建筑联盟将组织开展我国被动式超低能耗建筑评价标识（以下简称"评价标识"）工作。

评价标识工作面向我国已建成及在建项目，自愿申请。评价标识的评审与颁发以单栋建筑为对象，不限制建筑类别和建筑功能。评价标识评审程序和办法见《被动式超低能耗建筑评价标识管理办法（暂行）》，请有意向的单位和项目按《被动式超低能耗建筑评价标识管理办法（暂行）2016 版》要求开展申报工作。

联系人： 张时聪 吕燕捷

联系电话：010-64693277

附件 1：《被动式超低能耗建筑评价标识管理办法（暂行）2016 版》

附件 2：评审材料列表

附件 3：被动式超低能耗建筑基本信息表

中建联被动式超低能耗建筑联盟

2016 年 8 月 10 日

Figure 2-4 The Passive Ultra-low energy building certification

2.3 Japan

According to the International Energy Agency (IEA), the buildings sector in Japan became the largest energy end-user in 1999. In 2005, the buildings sector consumed 116 million tons of oil equivalent (Mtoe), or 33% of Japan's total final energy use. Reducing building energy use and related CO_2 emissions has long been a stated priority of Japan's energy policies [11].

2.3.1 Policies

Japan was hit hard by the 1973 oil crisis, as its oil consumption contributed to 80% of its total primary energy demand that time. Since then, the Japanese government has been committed to making energy efficiency one of its priorities in national development.

Today, Japan has one of the most efficient economies in the world as measured by energy intensity. Japan's Rational Use of Energy, or Energy Conservation, Law was first issued in 1979. Initially, it was primarily focused on promoting energy efficiency in the industrial sector. The law served as the foundation of Japan's energy efficiency policies and was updated numerous times, including in 1983, 1993, 1998, 2002, 2005 and 2008. The 2002 revision required that owners of new commercial buildings larger than 2,000 square meters submit energy saving plans to the government. The 2005 revision, which took effect in 2006, strengthened energy efficiency measures for residential buildings and the construction sector. Owners of buildings with over 2,000 square meters must submit energy saving plans for renovation permits (IEA, 2008b, c, d and e). Recent revisions to the Energy Conservation Law expand the number of buildings for which energy saving plans are required; the revisions go into effect in 2009. The revisions require owners of small and medium-sized buildings (300 to 2,000 square meters) to submit energy saving plans before construction or renovations. Also, construction companies building more than 150 houses per year would need to improve the energy performance of the houses they built [11].

The Building Energy Efficiency Act

The Building Energy Efficiency Act is an act on the improvement of energy consumption performance of buildings which is established in July 8, 2015. The two main ideas of the act are:

1) Regulatory measures for mandatory compliance with energy efficiency standards for large-scale non-residential buildings

2) Incentive measures such as a labeling system displaying compliance with energy efficiency standards and exception of floor-area ratio regulation for certified building

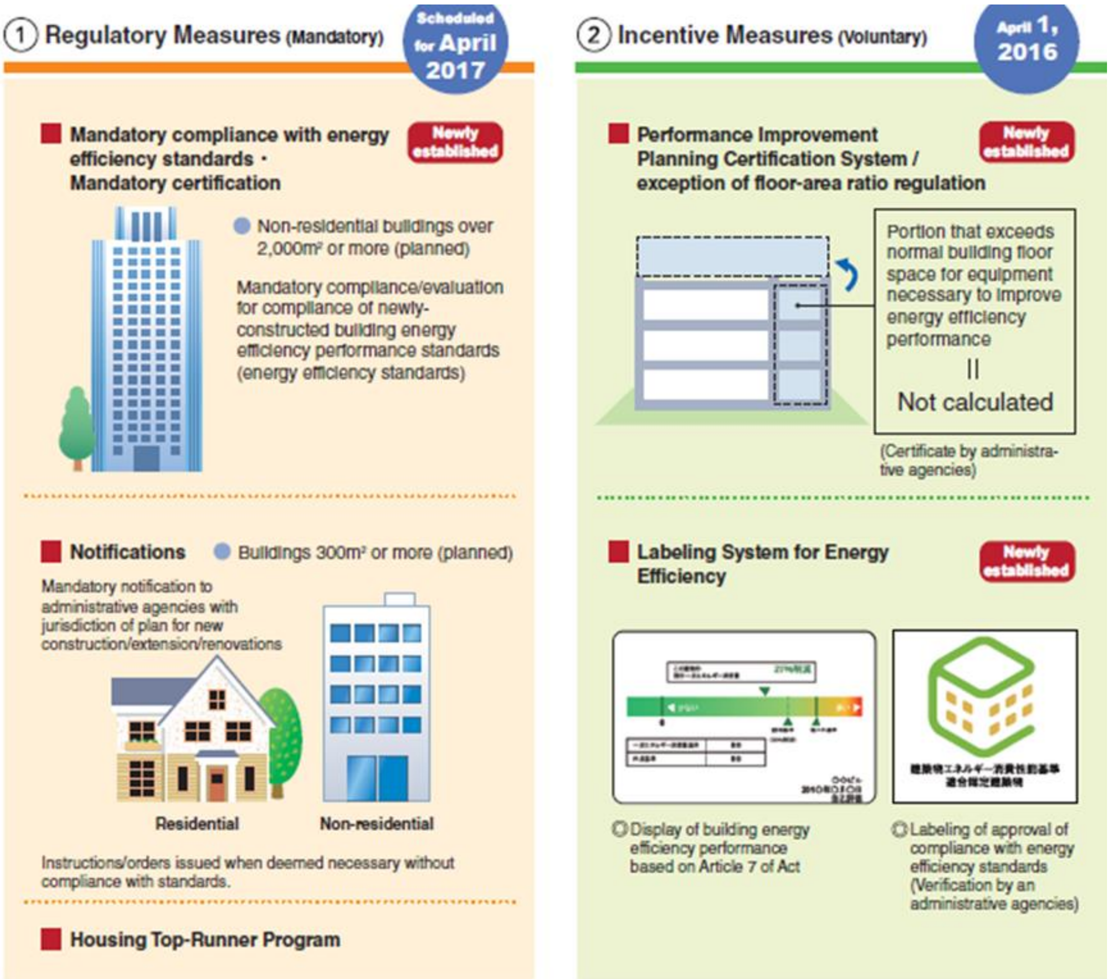


Figure 2-5 The Building Energy Efficiency Act

Supervised by: MLIT Issued by: Institute for Building Environment and Energy Conservation (IBEC)

Overview of the Act on the Improvement of Energy Consumption Performance of Buildings

2.3.2 Codes and standards

Under the Energy Conservation Law, Japan has issued a set of building energy standards for commercial and residential buildings. The Criteria for Clients on the Rationalization of Energy Use for Buildings (CCREUB) was first issued in 1979, and the newest version was released in 1999 by the Ministry of International Trade and Industry (MITI) and the Ministry of Construction (MoC). There are two building energy standards related to residential buildings: (1) Design and Construction Guidelines on the Rationalization of Energy Use for Houses (DCGREUH), issued by

MoC in 1980, and later revised in 1992 and 1999; and (2) Criteria for Clients on the Rationalization of Energy Use for Houses (CCREUH), issued by MITI and MoC in 1980, and later revised in 1992 and 1999[11].

According to recent statistics, houses that comply with the latest building energy standard consume 40% less energy than houses without insulation, offices that meet the latest standard use 75% less energy than those that do not (MLIT, 2007).

The Ministry of Land, Infrastructure and Transport (MLIT) issued the “Basic Program for Housing” in 2006, which aimed to improve housing standards by 2015. Two of the 21 targets MLIT announced include (1) 40% of housing should have energy saving measures, and (2) the life span of housing should be increased from 30 years in 2003 to 40 years by 2015 (IEA, 2008a). Buildings in Japan typically have a shorter life span than those in most other APP economies. This fast turnover of buildings presents on-going opportunities to create a more efficient building stock, but it also means that the buildings designed for short lives may not be built with as much attention to energy efficiency.

2.3.3 Incentives and subsidies

Besides the incentives, there is also penalty. Building sector in Energy Conservation Law:

Building Sector

The term “specified buildings” in the Japan according to the Energy Conservation Law refers to commercial buildings must have a total floor area of at least 300 square meters. Residential buildings can be smaller and there are no set limits on the size. Owners of specified buildings, who intend to construct 6 or extensively modify the buildings, are required to submit a mandatory report on the planned energy conservation measures to the authorities before construction. After the completion of construction or modification, the property owners must also submit periodic reports on the maintenance of the buildings with respect to energy-saving measures. If the local authority finds the energy-saving measures to be insufficient, the authority provides guidance and advice to the owners for improvement. If an owner does not follow the authority’s advice and instructions for improvement, the authority can publicize the owner’s name on a list for non-compliance (The Energy Conservation

Center, 2007). The 2008 edition of the law added penalties for non-compliance of up to JPY 1,000,000 or about US$11,000.

2.3.4 Certification

Building-Housing Energy-efficiency Labeling System

The Building-Housing Energy-efficiency Labeling System(BELS) is one of the third-party verification systems established by the 2016 Ministry of Land, Infrastructure, Transport and Tourism Notification No. 489 "Guidelines concerning the labeling of building energy consumption performance" (hereinafter "Guidelines") based on Article 7 of the Act on the Improvement of Energy Consumption Performance of Buildings (Building Energy Efficiency Act).

It is a system where BELS-registered agencies registered with the Association for Housing Performance Evaluation & Labeling conduct the energy efficiency performance evaluations and labeling. A star rating is given according to the labeling content and each corresponding BEI value (Building Energy Index; a value obtained by dividing the design primary energy consumption by the standard primary energy consumption, that acts as an index for energy efficiency standards) based on the Guidelines.

Figure2-6 The CASBEE Certification System

The Comprehensive Assessment System for Built Environment Efficiency (CASBEE) Certification System is a comprehensive assessment of the quality of a building, evaluating features such as interior comfort and scenic aesthetics, in consideration of environment practices that include using materials and equipment that save energy or achieve smaller environmental loads. The CASBEE assessment is ranked in five grades: Superior (S), Very Good (A), Good (B+), Slightly Poor (B-) and Poor (C).

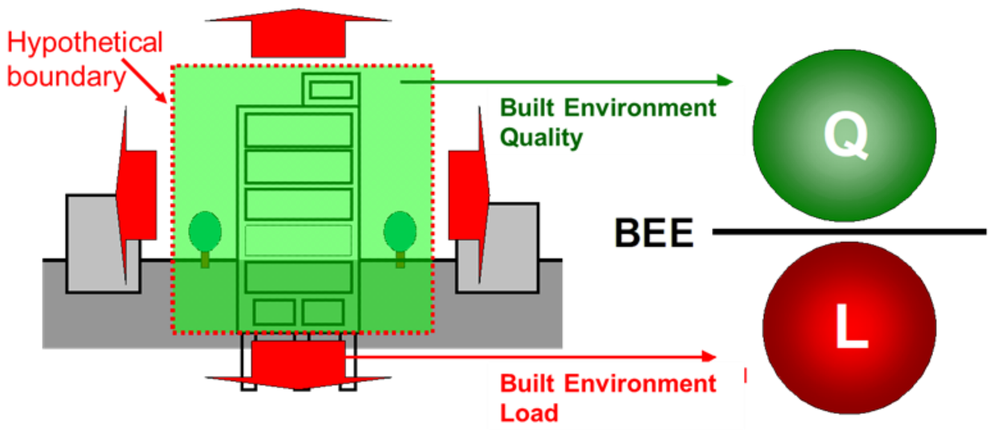


Figure 2-7 CASBEE Certification

CASBEE was developed by a research committee established in 2001 as part of a joint industrial/government/academic project. The CASBEE assessment tools were developed on the basis of the following three principles:

1) Comprehensive assessment throughout the life cycle of the building

2) Assessment of the Built Environment Quality and Built Environment Load

3) Assessment based on the newly developed Built Environment Efficiency (BEE) indicator

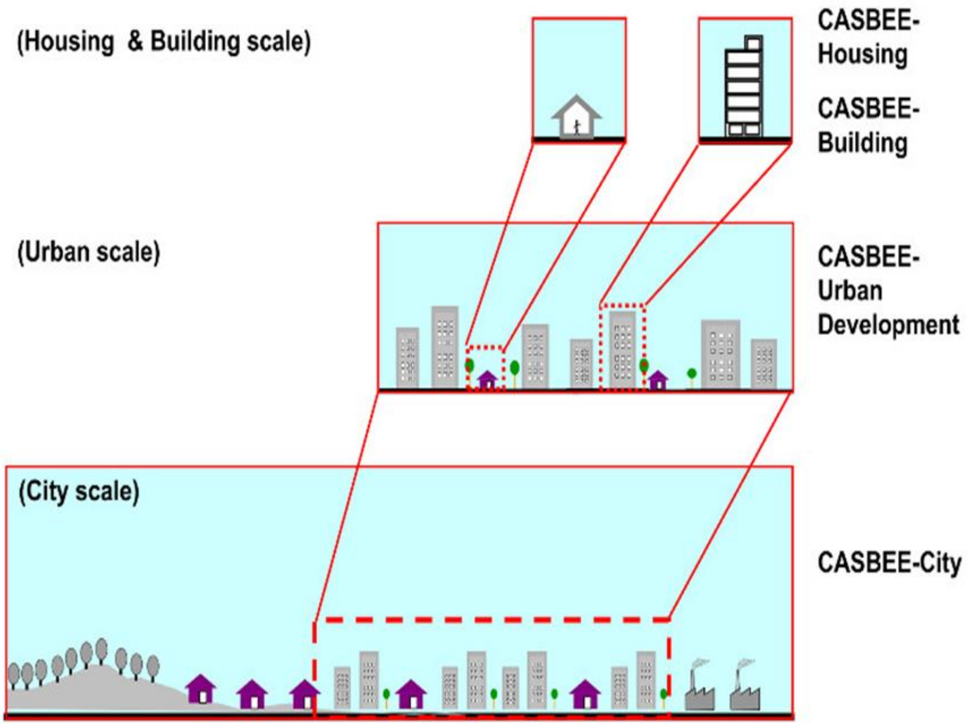


Figure 2-8 CASBEE Certification system

As shown in the figure 2-8, CASBEE-Housing and CASBEE-Building are applied for individual houses and buildings to assess their environmental performance. CASBEE-Urban Development is used to evaluate environmental performance of urban blocks and town development. CASBEE-City evaluates environmental performance on a local government scale. These are assessed based on BEE indicators by CASBEE.

2.4 Korea

As an economy with very scarce natural resources, Korea imports 96% of its energy and this has become its one of the biggest economic burden. According to the statistics in 2014, the energy import cost 173 billion USD (33.1% of total import) and this cost is expected to be steadily increased.

In order to respond to the COP21, Korean government plan to reduce 37% of the GHG emissions from BAU by the year 2030. This will call for a 13.7% of reduction from building sector.

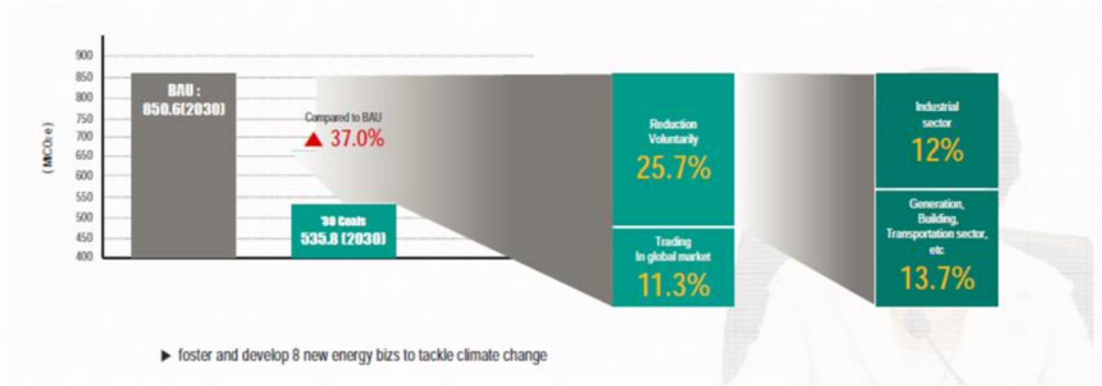


Figure 2-9 Korean government's GHG emissions goal

2.4.1 Policies

The Korean government issued the Rational Energy Utilization Act (REUA) in 1979 to promote the rational and efficient utilization of the energy, and reducing the environmental damages caused by the consumption of energy.

Recognizing that its economy is largely fueled by imported fossil fuels, Korea has set the three E's (energy security of supply, economic efficiency and environmental protection) as its national goals for achieving sustainable economic development. The Ministry of Knowledge Economy (MKE), or the former Ministry of Commerce, Industry and Energy (MOCIE), is in charge of national energy policy [26].

From the mid-1970s to the mid-1990s, Korea focused on improving energy efficiency in the industrial sector. Since the late 1990s, the government has shifted gears to promote energy efficiency in the buildings and transportation sectors [27]. For example, the government set long-term energy conservation goals for the buildings sector. These goals focused on reducing emissions by 6% in this sector by 2020, as compared with business-as-usual emissions [28].

In order to reduce the dependence on external source of energy which have occupied 96.4% of total energy demand, the Korean government has set a long-term goal to improve the energy efficiency in 2008: By 2030, the national energy efficiency will be improved by 46%, which means to improve energy intensity to 0.185(toe/1,000$) through National Energy Master Plan ('08~'30) (Figure 2-10).

Figure 2-10 Energy demand and Target (08-30)

This means a 2.5% annual improvement of energy efficiency until 2030. The Korean government has developed and implemented many energy efficiency policies to complement the 30% emissions reduction target, for example: stronger building design codes.

2.4.2 Codes and standards

Korea issued its first mandatory building standard on insulation levels in 1977, followed by building energy standards for several types of building in the next two decades. These standards covered offices, hotels, hospitals and residential buildings. The separate energy standards for respective building types were integrated into the Building Design Criteria for Energy Saving (BDCES) in 2001, which is mandatory for all types of buildings where high energy consumption is expected. The BDCES was a product of intensive revision of existing standards and review of building energy codes of several countries, including the U.S., the U.K., Germany, Japan and Canada. The Korean government felt that complex codes like the U.S. ones may provide a detailed blueprint, but the government preferred a simple approach like the Japanese codes in order to ease implementation in Korea (Lee 2006). The BDCES underwent several revisions after 2001, with the latest in November 2008. This document reflects the November 2008 version of the standard [26].

Building Design Criteria for Energy Saving (2010)

It is a mandatory policy applied in new residential and existing residential buildings.

The building envelope requirements in the BDCES, such as insulation material standards, are mandatory for all new buildings. More detailed provisions regulate large new buildings6, including: (1) apartment/condominium buildings with over 50 households, (2) education/research or office buildings greater than 3,000 square meters, (3) hotels/motels and hospitals over 2,000 square meters, (4) public bathhouses and swimming pools over 500 square meters, (5) wholesale/retail stores (e.g. department stores) with a centralized cooling/heating system and over 3,000 square meters, or (6) performance halls, town halls and stadiums with total floor area over 10,000 square meters.

The BDCES is a prescriptive-based building energy standard. It contains four main sections (Table 2-3): “Construction Design,” “Machinery Design,” “Electric Facility Design” and “Renewable Energy Facility Design”. Each section outlines “mandatory items” and “recommended items.” In addition, there are “Supplementary Rules” mandating that multi-purpose buildings be approved for each relevant purpose.

Table 2-3 Passive House Criteria in Germany and Energy Saving Criteria in Korea

Components	Passive House criteria in Germany	Energy saving criteria 2017 in Korea
1. Building envelope		
Wall insulation	U≤0.15 W/㎡K	U≤0.17 (0.26) W/㎡K
Roof insulation	U≤0.15 W/㎡K	U≤0.15 (0.15)W/㎡K
Floor insulation	U≤0.15 W/㎡K	U≤0.15 (0.18)W/㎡K
Window	U≤0.8 W/㎡K	U≤1.0 (1.50) W/㎡K
Door	U≤1.0-1.2 W/㎡K(2.0)	U≤1.40 (1.50) W/㎡K
Thermal bridge	U≤0.01 W/mK	-
Air-tightness	n50≤0.6 h^{-1}	-
2. System		
Efficient heating system	89.5% efficient	Boiler efficiency 87%
Air change rate	0.4 h^{-1} with heat recovery	0.5 h^{-1}

Besides the mandatory building energy standard, the BDCES, Korea has also promoted an array of voluntary programs to improve building energy efficiency.

2.4.2.2 Energy Efficiency Labeling Program for Buildings

Newly built or renovated dwellings with more than 18 households are classified into three grades depending on the application of energy-saving features and equipment. A building which surpasses a certain performance standard is provided with a Certificate of Building Energy Efficiency, which makes the building eligible for low-interest rate construction loans. The Korean government has progressively expanded the energy efficiency labeling program by targeting office buildings in 2004 – 2010 [29].

2.4.2.3 Green Building Certification Program

The Green Building Certification Program applies environmental lifecycle assessment to the buildings sector, including production of materials, design, construction, maintenance and building demolition. The program aims to improve environmental performance, reduce energy use and the related GHG emissions [29].

2.4.3 Incentives and subsidies

The difficulties and obstacles in promoting zero energy building in Korea mainly focus on the following aspects:

1) The ZEB market is more difficult to form. Due to the small demand in Korea, there are only few types of passive technology building materials made in Korea, which requires the use of expensive imported products. So it is hard to cultivate the zero energy building industry without any supporting policies and regulations.

2) Comparing to normal buildings, the cost of zero energy buildings will increase 30% and this will significantly affect the developer's activity if the government's support for subsidies and taxation is insufficient.

3) The Korean government has provided subsidies for the application of renewable energy systems, but for passive technology application, which can have more significant energy saving effect, there is a lack of subsidies.

2.4.3.1 Fiscal and tax policy

The above factors have led to an increase in the cost of zero-energy building construction, which also hindered the industrialization of ZEB component promotion.

Realizing this, the Korean government promulgated a series of fiscal incentives that help promoting the development of zero energy building:

1) Building deregulation. Relax the plot ratio and building height limits, increase 15% under the current standard to offset some of the construction incremental costs.

2) Proper tax deduction. Consumers that purchase zero energy building/home will receive a 15% cut on proper tax during the first five years.

3) Housing provident fund loans. The low interest supported by the housing provident fund provides support for the green renovation project of existing buildings. Meanwhile, more than 20% of the loan limit will be available for the applicants.

4) Corporate income tax. The zero energy building constructer and relevant component producer (like outer insulation material, high performance window) can exempt some of its income tax.

2.4.3.2 Project subsidy

Projects that achieved the zero energy building certification can get the relevant subsidies.

1) For passive technology. For the project that adopts passive technology, like high performance building envelope and windows, the government will grant a certain proportion of the incremental cost, 15% for residential building, and 50% for public buildings.

2) For renewable energy. For the project that applied renewable energy, like solar energy, ground source heat pump, or other renewable energy system can apply for the 50% of the system cost as subsidy.

3) Building Energy Management System. For the project that applied Building Energy Management System (BEMS) can apply for the 50% of the system cost as subsidy.

4) Technical support. The project stakeholder can get consulting support from zero energy center, get free of charge Certification fee, get technical support for ZEB &

BEMS

2.4.3.3 Subsidy for renewable energy system application

The Korean government issued the Renewable Energy Application Standard in 2010 and proposed that the proportion of renewable energy application will be raised to 11% by 2035. In 2015, a budget of $548.60 million was invested in the direction of renewable energy. The budget is mainly used for mandatory on-grid tariff subsidies for renewable energy and the construction of basic laws and regulations.

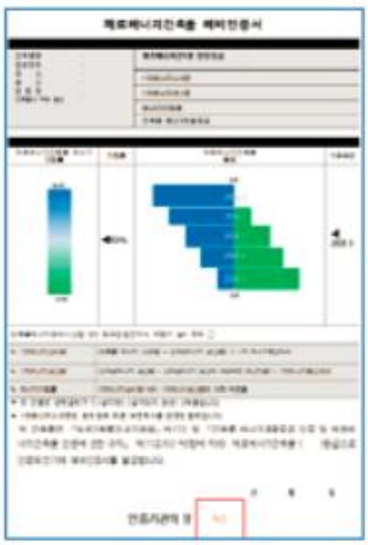
For the application of renewable energy, it is required that by 2020, for newly constructed and reconstructed public buildings with area of 1,000 m^2 or more, the renewable energy should cover 30% of the total energy demand. As for the incremental cost, the Korean government established $47.4 million subsidy for residential projects and $20 million subsidy for large scale projects.

2.4.4 Certification

ZEB in Korea Green Building Code is defined as the green building that is minimized building load and energy requirement by supply of new & renewable energy.

ZEB Certification System was started by Ministry of Land, Infrastructure and Transport and Ministry of Trade, Industry and Energy from January 2017.

ZEB Certification in Korea Green Building Regulation is defined as more than 20% energy self-reliance rate and more than BER 1++ grade building.



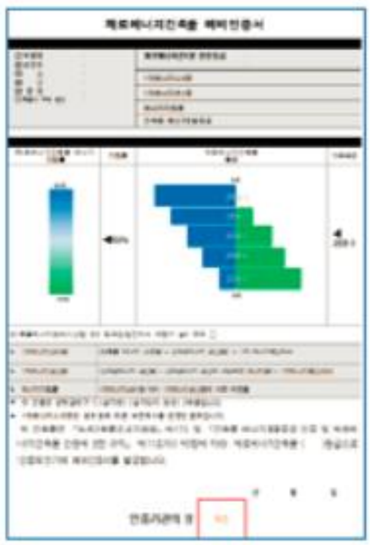


Figure 2-11 ZEB Certification System

2.5 The United States

2.5.1 Policies

In United States, NZEB promoting policies are taken according to the right of the building ownership.

1) Executive Order 13514

The Federal government owns approximately 445,000 buildings with total floor space of over 3.0 billion square feet, in addition to leasing an additional 57,000 buildings comprising 374 million square feet of floor space. With the goal of achieving zero-net-energy, the federal government enacted the Executive Order 13514, which is an executive order titled Federal Leadership in Environmental, Energy, and Economic Performance that U.S. President Barack Obama issued on 5 October 2009 [30].

This executive order mandates federal buildings and leases to meet Energy Efficiency Guiding Principles. The timeline and means for achieving the stated goal of zero-net-energy federal buildings can be summarized as follows:

- By 2020, all planning for new Federal buildings should achieve Zero-Net-Energy by 2030.
- Zero-Net-Energy goals are to be incorporated into the process of buying or leasing new government properties.
- At least 15% of existing federal buildings and leases need to meet the Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings by 2015.

2) The Energy Independence and Security Act of 2007

The **Energy Independence and Security Act of 2007 (EISA 2007)** is an Act of Congress concerning the energy policy of United States, which aims at the same objectives with NEP. EISA 2007 authorizes DOE to host industry-led Commercial Building Energy Alliances and to establish specific goal for commercial buildings [31]:

- Net zero energy use in all new commercial buildings constructed by 2030

- Net zero energy use in 50% of United State commercial building stock by 2040
- Net zero energy use in the entire United States commercial building stock by 2050

As for residential buildings, the incentive green building competition Energy Free Home Challenge (EFHC) is opened to teams around the world in 2010. The competition encouraged both design innovation and cost reduction with the purposes of popularizing the concept of “Zero net energy” home and “Zero net cost” home.

3) The Executive Order 13693

The Executive Order 13693 (EO 13693), "Planning for Federal Sustainability in the Next Decade," issued on March 19, 2015, directed agencies to establish agency-wide energy efficiency and renewable energy targets [32]. As with the Paris Agreement, parts of the business community have encouraged the U.S. to maintain its commitments to energy efficiency and renewable energy. If EO 13693 is rescinded at a later date, agencies would be permitted to withdraw their sustainability plans – save for the Department of Defense, whose 25 percent renewables by 2025 target was codified in the National Defense Authorization Act of 2007[31].

EO 13693 proposed clear requirement on improvement of building efficiency, performance, and management by: Ensuring, beginning in fiscal year 2020 and thereafter, that all new construction of Federal buildings greater than 5,000 gross square feet (>464.5 square meters) that enters the planning process is designed to achieve energy net-zero and, where feasible, water or waste net-zero by 2030.

4) California ‘s Long Term Energy Efficiency Strategic Plan

In California, all new residential construction will be zero net energy by 2020, all new commercial building achieve net zero energy goal by 2030. Table 2-4 show the strategy of NZEB development:

Table 2-4 California ‘s Long Term Energy Efficiency Strategic Plan

Focus Area	Goal	Now	2020	2025	2030
Residential Buildings	New Construction NZEB[1]		**100%**		
	Existing Homes (reduction relative to existing stock)[1]		40%		
Commercial Buildings	New Construction NZEB[1]				**100%**
	Existing NZEB[1]				50%
State Buildings	New Construction and Major Retrofit NZEB[2]		50%	**100%**	
	Existing NZEB (by square footage)[2]			50%	

5) California State Assembly Bill 32

California State Assembly Bill 32 (AB32), or the Global Warming Solutions Act of 2006, is an environmental law passed by the California State Legislature and signed into law by Gov. Arnold Schwarzenegger on September 27, 2006 [33]

AB 32 says that by the year 2020, the level of emissions of greenhouse gases in the state must be reduced to the level that such emissions had in 1990. Regulatory and market mechanisms to achieve "real, quantifiable, cost effective reductions of GHGs," phased in between 2007 and 2012:

- Cap-and-trade
- Monetary incentives
- Regulatory measures (e.g., new building energy efficiency standards)

It is estimated that reducing the state's greenhouse gas emissions to 1990 levels would require an approximate 25% reduction over the level of emissions in 2006, the year the bill was signed. This also means the state energy target: 32,000 gigawatt hours GWh and 84.3 MJ of energy saved from business as usual (BAU) projections for 2020 (PG&E 2012).

6) California Public Utilities Commission (CPUC) "Big Bold Energy Efficiency Strategies (BBEES)":

1. All new residential buildings in California will be NZE by 2020;
2. All new commercial buildings will be NZE by 2030;
3. Heating, ventilation, and air conditioning (HVAC) will be transformed to ensure that its energy performance is optimal for California's climate; and

4. All eligible low-income customers will be given the opportunity to participate in the low income energy efficiency program by 2020 (PG&E 2012).

2.5.2 Codes and standards

Building codes and standards for energy conservation are the most basic and powerful measures of improving building energy efficiency and promoting NZEB development. Energy codes and standards play a vital role by setting minimum requirements for energy-efficient design and construction. They outline uniform requirements for new buildings as well as additions and renovations. As the forerunner among the APEC economies, the US has done a lot of work on making, implementing and upgrading building energy codes and stands.

Energy codes specify how buildings must be constructed or perform, and are written in mandatory, enforceable language. States or local governments adopt and enforce energy codes for their jurisdictions. Energy standards describe how buildings should be constructed to save energy cost-effectively. They are published by national organizations such as the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). They are not mandatory, but serve as national recommendations, with some variation for regional climate. States and local governments frequently adopt the national standards as mandatory building energy codes or use the standards as the technical basis for developing their own energy codes. Building energy standards are written in mandatory, enforceable language, making it easy for jurisdictions to incorporate the provisions of the energy standards directly into their laws or regulations. Energy use targets of building energy codes are also proposed by authoritative institutes and organizations to illustrate the developing blueprint.

2.5.2.1 ANSI/ASHRAE/IESNA Standard 90.1

ANSI/ASHRAE/IESNA Standard 90.1, Energy Standard for Buildings except Low-Rise Residential Buildings (2016), is published as a consensus standard to provide minimum requirements for the energy-efficient design of new and renovated or retrofitted buildings. It offers, in detail, the minimum energy-efficient requirements for design and construction of new buildings and their systems, new portions of buildings and their systems, and new systems and equipment in existing buildings, as well as criteria for determining compliance with these requirements. It is an indispensable reference for engineers and other professionals involved in design of buildings and building systems.90.1 is adopted by reference by the National Fire Protection Association (NFPA), so if a locale adopts NFPA, it adopts 90.1. The International Code Council has also developed a single set of regulatory documents for use by states and other locales. The 2015 IECC has two paths within its chapter 5. The first is to comply with 90.1-2013. Or one can follow the prescriptive requirements of the rest of Chapter 5.

Standard ASHRA 90.1 has been a benchmark for commercial building energy codes in the United States and a key basis for codes and standards around the world for more than 35 years. 90.1 is written in a code intended language as minimum requirements so it does not necessarily provide exemplary or state-of-the-art design guidance. ASHRAE Standard 90.1 is on continuous maintenance and is republished on a three year cycle. The current version is ASHRAE 90.1-2016 [34].

The 2016 edition has been expanded to include new features and more detailed requirements, and is approximately 8% more stringent that ASHRAE 90.1-2013.

2.5.2.2 ASHRAE Advanced Energy Design Guides (AEDG)

The ASHRAE Advanced Energy Design Guides (AEDG) are a series of publications designed to provide prescriptive recommendations for achieving 30% energy savings over the minimum code requirements of ANSI/ASHRAE/IESNA Standard 90.1 in eight U.S. climate zones. They are developed by a committee of experts and undergo peer review but are not developed through a consensus process. They show a way, but not the only way, to achieve 30% savings.

The first step in the process toward achieving a net zero energy building which is defined as a building that, on an annual basis, draws from outside resources equal or less energy than it provides using on-site, renewable energy sources. The Guides have been developed in collaboration with these partnering organizations[7]: The American Institute of Architects (AIA), the Illuminating Engineering Society of North America (IES), the U.S. Green Building Council (USGBC), and the U.S. Department of Energy (DOE). The New Building Institute (NBI) participated in the development of the initial Guide.

As 90.1 gets more stringent, the standard will eventually surpass the energy savings recommended in the 30% AEDGs[8], however, they will remain excellent tools for energy-efficient design of buildings for quite some time. These guides provide a good starting point for anyone looking for a prescriptive, simple way to improve their energy efficiency and remain a good resource due to the information contained in the how-to tips. Each of the AEDGs (except the Small Office guide) lists the average savings as compared to 90.1-2004, additional AEDGs at 50%.

Advanced Energy Design Guides (AEDGs) are currently planned to be a series of guides that provide 30% energy reduction guidance, 50% energy reduction guidance, and 70% energy guidance. The committee recommends that the 70% energy reduction guides scheduled for completion by 2015 be modified to become net zero energy design guides. These guides would offer strategies that provide design guidance for 70% energy savings and strategies for on-site renewable energy concepts that result in NZEBs.

2.5.2.3 ASHRAE Standard 189.1-2017

ASHRAE Standard 189.1-2017, Standard for the Design of High-Performance, Green Buildings except Low-Rise Residential Buildings, is intended for buildings that wish to exceed the minimum requirements of Standard 90.1 [35].

The purpose of this standard is to provide minimum requirements for the siting, design, construction, and plan for operation of high-performance green buildings to (a) balance environmental responsibility, resource efficiency, occupant comfort and well being, and community sensitivity, and (b) support the goal of development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This standard provides minimum criteria that:

a) Apply to the following elements of building projects:

   1. New buildings and their systems

   2. New portions of buildings and their systems

   3. New systems and equipment in existing buildings

b) Address site sustainability, water use efficiency, energy efficiency, indoor environmental quality (IEQ), and the building's impact on the atmosphere, materials, and resources.

The provisions of this standard do not apply to single-family houses, multi-family structures of three stories or fewer above grade, manufactured houses (mobile homes) and manufactured houses (modular), or buildings that use none of the following: electricity, fossil fuel, or water. This standard is a compliance option of the International Green Construction CodeTM (IgCCTM).

When the new versions of Standards 90.1 and 189 are issued, the AEDGs and other energy-related documents need to be updated.

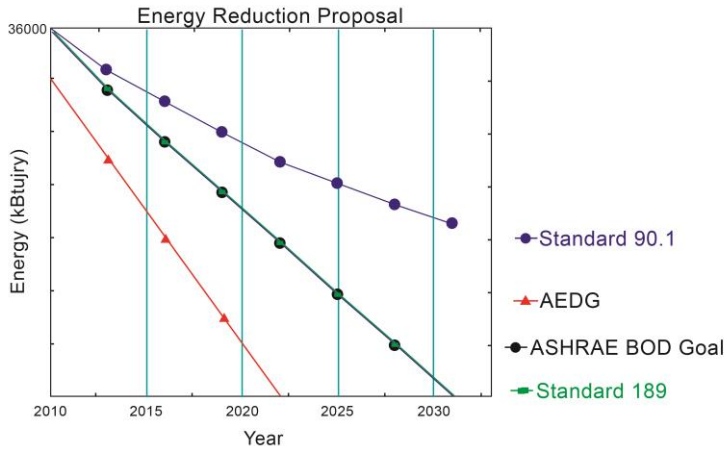


Figure2-12 Comparisons of different standards in energy reduction proposal

Source: ASHRAE, 2008

2.5.2.4 International Energy Conservation Code (IECC)

The IECC is typically published every three years, though there are some exceptions. In the last two decades, full editions of the MEC came out in 1989, 1992, 1993, and 1995, and full editions of the IECC came out in 1998, 2000, 2003, 2006, 2009, 2012 and 2015.

The IECC can be categorized into two general eras: 2003 and before, and 2004 and after. This is because the residential portion of the IECC was heavily revised in 2004. The climate zones were completely revised (reduced from 17 zones to 8 primary zones in 2004) and the building envelope requirements were restructured into a different format. The code became much more concise and much simpler to use. These changes complicate comparisons of state codes based on pre-2004 versions of the IECC to the 2009 IECC [36].

2.5.2.5 California's Building Energy Efficiency Standards

California’s energy code is considered to be one of the most aggressive and best enforced energy code in the United States, and has been a powerful vehicle for advancing energy-efficiency standards for building equipment. Many specifications are performance-based, offering flexibility for designers. The code also stands out because it includes field verification requirements for certain measures and reports high compliance rates overall. The most recently adopted 2016 code, effective January 1, 2017, is mandatory statewide and exceeds 2015 IECC standards for residential buildings and meets or exceeds ASHRAE/IESNA 90.1-2016 for commercial buildings.

The Energy Commission's energy efficiency standards have saved Californians more than $74 billion in reduced electricity bills since 1977. The California Energy Commission has partnered with the State wide Codes & Standards Program to provide training and resources for building officials. California’s building energy code can help save energy, keep our air cleaner and offset the need to build new power plants. We understand it can be quite technical and difficult to navigate new standards, especially when time and resources are limited.

California's Building Energy Efficiency Standards are updated on an approximately three-year cycle. The 2019 Standards will continue to improve upon the current 2016 Standards for new construction of, and additions and alterations to, residential and nonresidential buildings. The 2016 Standards has come into effect on January 1, 2017.

The Title 24 (part 6) Building Energy Efficiency Standards [37] upcoming triennial update cycles will need to address ZNE in response to the policy goals for 2020. Codes and Standards are the most important push mechanism available for implementing policy goals. Each update of the standards makes them more stringent and moves the needle towards higher efficiency. Title 24 also provides for the adoption of “reach codes,” which are higher level than the base code and typically become the precursor to base code in the subsequent update. Achieving ZNE will necessitate some renewable generation but this can only be required in code if analysis determines that this meets standard cost effectiveness criteria. The 2013 standards have been adopted and went into effect as of Jan 1, 2014 [38], and the current 2016 standards went into effect on January 1 2017. Typically, the standards’ stringency increases at the rate of 12-15% in each cycle.

A newly constructed residential building built to the prescriptive requirements of the 2013 Standards will use 25% less energy for lighting, heating, cooling, ventilation, and water heating than one built to the prescriptive requirements of the 2008 Standards. For nonresidential buildings, there will be a 30% reduction in energy use [39].

The major changes of the Standards for 2013 can be concluded as follows [38]:

- The first Standards update designed to put newly constructed homes on a path to achieve California's Zero Net Energy goals by 2020.
- The first Standards update to establish a photovoltaic compliance option, which allows a portion of the energy generated by a solar electric system to count toward meeting the energy budget in the performance Standards.
- Wall insulation requirements for residential buildings are increased to prevent heat transfer and reduce HVAC loads.
- Process equipment installed in grocery stores, commercial kitchens, data centers, laboratories, and parking garages is now covered by the Standards.
- All 3/4-inch and larger residential hot water pipes must be insulated to avoid wasting water and energy, and reduce the time it takes to get hot water to where it is needed.

The 2013 standards update codes for lighting, space heating and cooling, ventilation, and water heating. These standards add approximately $2,000 to the new residential building construction costs. Estimated energy savings to homeowners, however, is more than $6,000 over 30 years. In total, these standards are estimated to save 200 million gallons of water (equal to more than 6.5 million wash loads) and avoid 170,500 tons of greenhouse gas emissions a year.

The significant changes to the Building and Standards code are the first update since California's energy agencies agreed upon a Zero-Net Energy goal: all new residential buildings by 2020 and new nonresidential buildings by 2030. The 2016 and 2019 Building Energy Efficiency Standards will move the state even closer to the Zero-Net Energy goal.

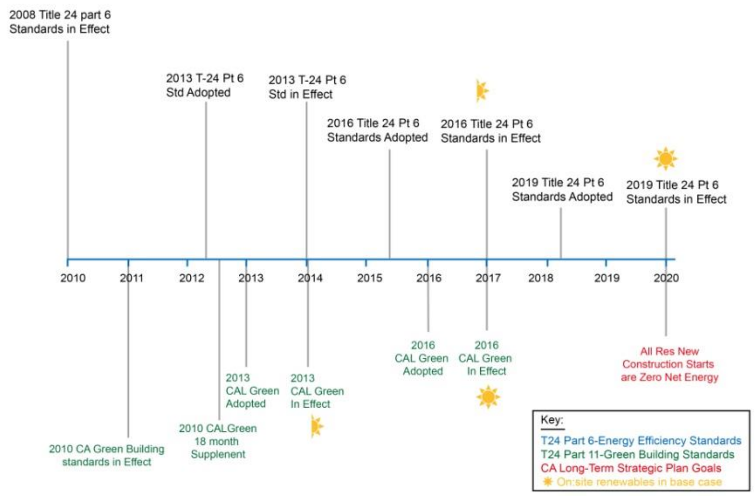


Figure2-13 Further path in residential[40]

"These new Title 24 standards will help California buildings function beautifully and economically. The most effective way to optimize building performance is during construction," said Commissioner Andrew McAllister who oversees the Energy Commission's energy efficiency division. "Standards are a foundational part of California's long-term goals for meeting our energy needs, conserving resources and protecting the environment."

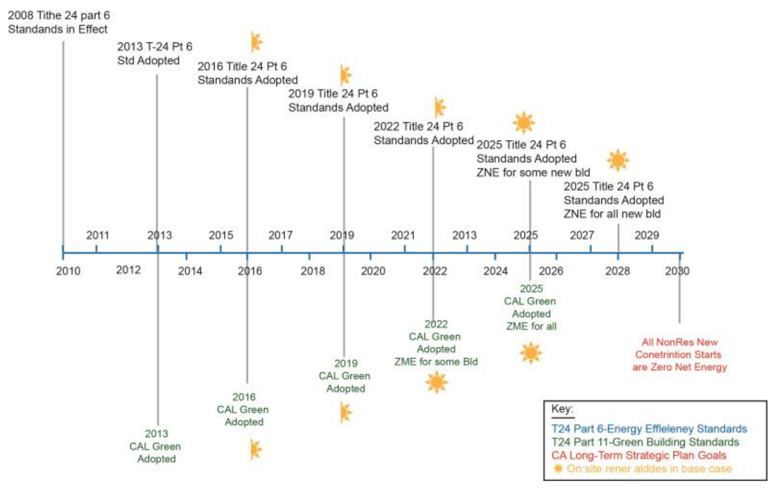


Figure2-14 Further path in commercial[40]

Prior to the Global Climate Action Summit held in San Francisco in September 2018, and due to the urgency of reducing building sector emissions to meet the 1.5 degrees Celsius target, Architecture 2030, with the support of the California Governor's Office and California Energy Commission, developed the ZERO Code for California (ZERO

Code). The ZERO Code is an energy code standard incorporating Title 24-2019 as the building efficiency standard coupled with onsite and/or offsite renewable energy requirements to reach Zero-Net-Carbon buildings. A number of California cities are currently in the process of adopting the ZERO Code.

2.5.2.6 The ZERO Code – An International Building Energy Standard

In October 2018, the U.N.'s Intergovernmental Panel on Climate Change warned that global warming "is likely to reach 1.5 degC between 2030 and 2052 unless immediate action is taken. APEC economies are already being impacted by climate change, and consumption of building sector fossil fuels will increase the risks in the coming decades. Avoiding the most serious impacts of climate change requires transforming the building sector within the next few years.

Only by eliminating greenhouse gas emissions from new building operations will increased existing building stock energy efficiency upgrades and renewable energy additions begin to reduce overall building sector emissions. To meet the Paris Agreement targets, action is needed today to implement zero-emissions building standards or codes worldwide.

While energy efficiency is the primary leverage point of the traditional building energy code structure, it must be complemented with impactful mechanisms for onsite renewable energy generation and procurement to reach zero-emissions standards.

The ZERO Code, developed and recently published by Architecture 2030, is the first international building energy standard that applies to all new commercial, institutional, and mid- to high-rise residential buildings, the prevalent building types being constructed in APEC cities today. The ZERO Code results in zero-net-carbon (ZNC) buildings, can be adopted immediately, and integrates cost-effective energy efficiency standards with on-site and/or off-site renewable energy resulting in ZNC buildings.

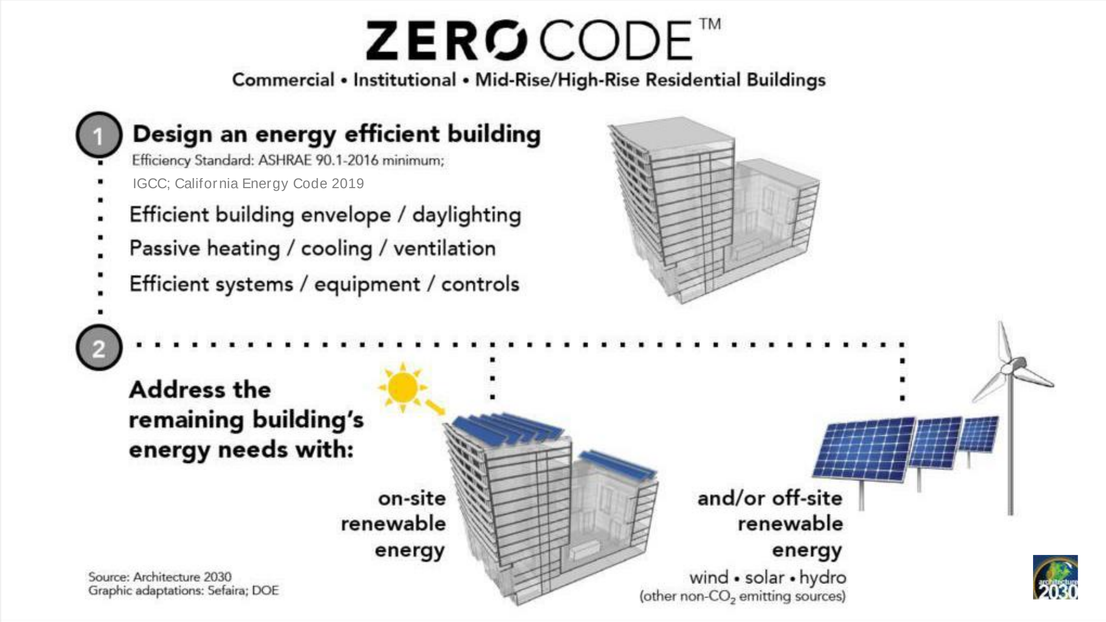


Figure2-15 The ZERO Code

The ZERO Code includes prescriptive and performance paths for building energy efficiency compliance based on current standards that are widely used by municipalities and building professionals worldwide.

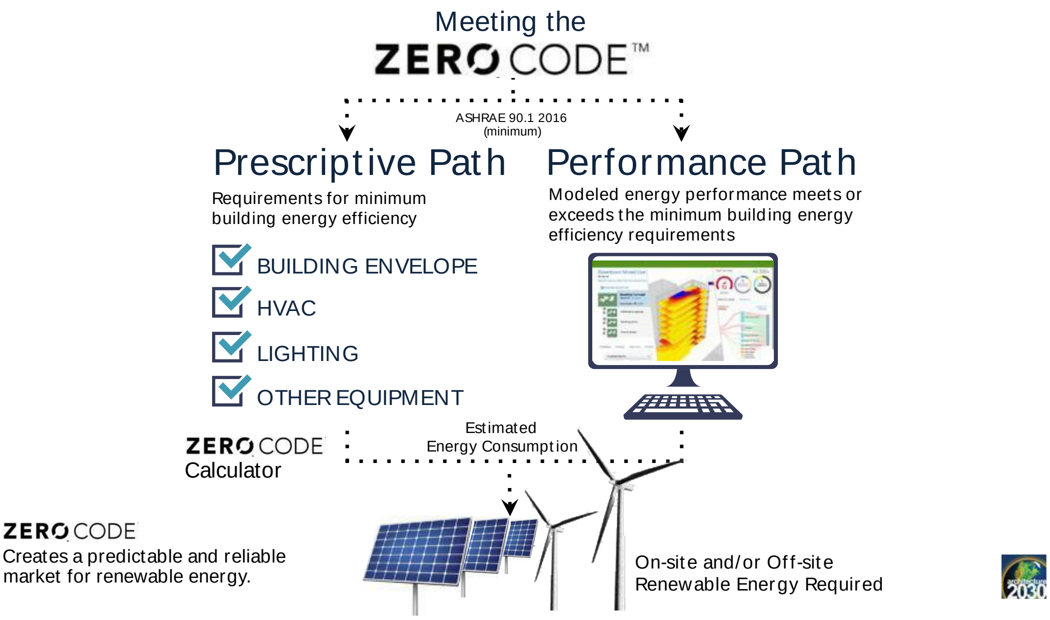


Figure2-16 The path to ZERO Code

The ZERO Code is supported by Energy Calculators that ease the implementation process and reduce errors when applying the prescriptive compliance path. An

Application Program Interface (API) for the international ZERO Code version of the software has been developed, enabling the software to be implemented as a website or an application for smart phones and tablets. Ultimately this approach will save years and valuable resources that would otherwise be spent on developing new compliance tools and mechanisms.

A technical support document is also available that describes potential options for off-site procurement of renewable energy within the context of codes and presents a process for evaluating and assigning a weight to each procurement method.

Complying with the ZERO Code entails first meeting the minimum prescriptive or performance requirements for building energy efficiency defined by ASHRAE Standard 90.1-2016. As part of a standardized and predictable process to continue to advance energy efficiency, new standards that exceed ASHRAE Standard 90.1-2016 have been incorporated into the ZERO Code, such as the 2018 International Green Construction Code (IgCC) and ASHRAE Standard 189.1-2017. Newer versions of ASHRAE 90.1, 189.1 and the IGCC will be incorporated as they are published. Once the minimum energy efficiency requirements are met, then the on-site and/or off-site renewable energy is calculated to achieve zero-net-carbon.

To download the ZERO Code and Technical Support Document visit https://zero-code.org/.

2.5.2.7 Embodied Carbon of Building Materials

Annually, embodied carbon is responsible for 11% of global GHG emissions and 28% of global building sector emissions. However, as we trend toward zero operational emissions, the impact of embodied emissions becomes increasingly significant. It is therefore crucial to address embodied emissions now to disrupt our current emissions trend, and because the embodied emissions of a building are locked in once the building is constructed and cannot be taken back or reduced.

The Carbon Smart Materials Palette, developed by Architecture 2030, contains an attribute-based approach to embodied carbon reductions in the built environment. It identifies key attributes that contribute to a material's embodied carbon impact and offers guidelines and options for emissions reductions. The Carbon Smart Materials Palette is designed to support and complement Life Cycle Assessments (LCAs) and

Environmental Product Declarations (EPDs), while providing highly impactful guidelines for low/no carbon material selections and specifications.

The Carbon Smart Materials Palette represents the best available knowledge and resources at this time. It will be updated with specifications and standards for low/no carbon building materials as more information becomes available.

Chapter 3 Technical roadmap to realize NZEB

3.1 Investigation of NZEB demonstrations in APEC area

To analyze the appropriate technologies for NZEB, this report investigate more than 100 NZEB demonstrations around APEC area. Many of the details of the projects have been shown in the report of Program EWG 02 2015A: APEC 100 Best Practices Analysis of Nearly/Net Zero Energy Building and during this report only the main technical strategies will be discussed.

3.2 Passive approaches

3.2.1 Building envelope

The building envelope is the front line of the building's interface with the exterior environment and climate. This means it plays a critical role in the implementation of passive strategies, and so should be integrated with decisions about orientation and massing, as well as with mechanical and electrical system design. The building envelope must balance the needs for passive strategies such as daylighting and natural ventilation that require the climate to permeate the interior, with the need for integrity and performance from a thermal energy perspective. So the high performance building envelope is the first step and the critical element in NZEB building design [41].

Walls and roofs

As for the largest external area of a building structure, roofs and walls are where most heat losses occurs. High performance envelope reduces heat loss in cold weather and keep out heat in hot weather. Figure 3-1 shows the roof U-value of the investigated NZEB best practices. During the investigation we found that the roof U-value that limited in the standards are various according to different economies, even different provinces or states, in the same economy.

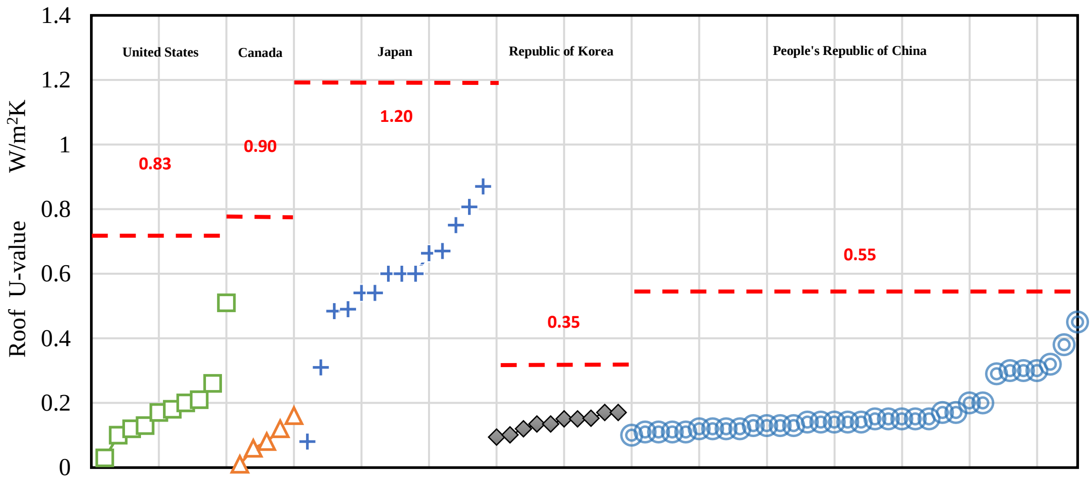


Figure 3-1 Roof U-value of NZEB

Figure 3-2 shows the External Wall U-value of the investigated NZEB best practices. The red line shows the standard limited value. Nearly all the best practices can reach a much lower U –value for external roofs and walls.

It should be noted that the high performance building envelope has been proved to be a most efficient and economical way to reduce building heating and cooling load, thus to cut down the heating and cooling demands, especially for regions that with high HDD values. But choosing proper insulation is also critical. The U-value for Japan projects are much higher than other economies, and this may also one reason that the energy consumption of the projects much higher than the others.

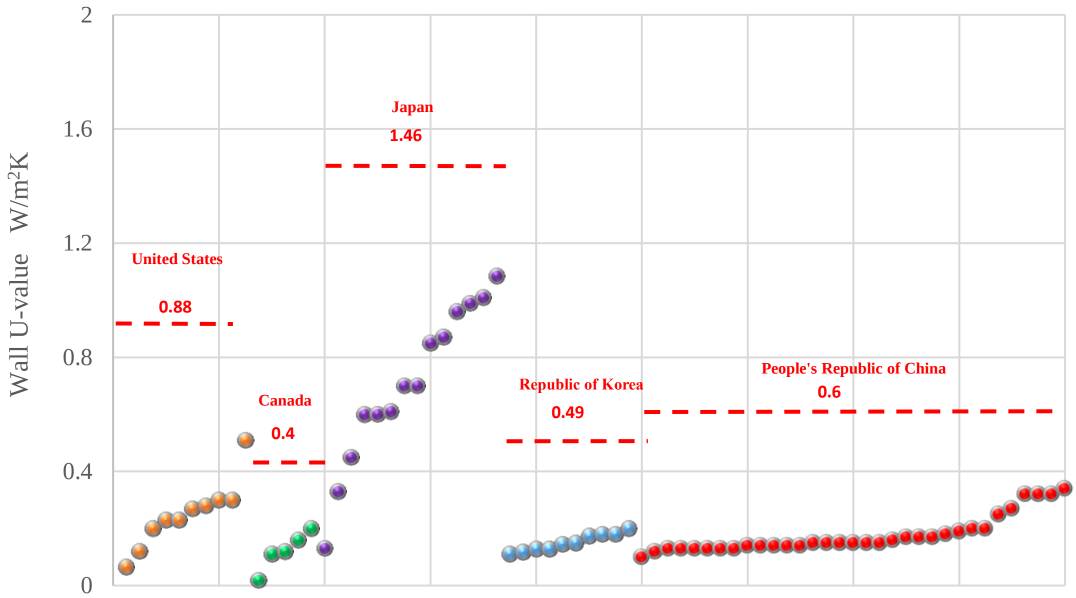


Figure 3-2 Wall U-value of NZEB

Windows

It is difficult to make windows and doors to have the same heat transfer capacity with roof and walls. Windows have an important impact on energy consumption. As is estimated, windows are most likely responsible for 5% to 10% of the total energy consumed in buildings. Comparing with walls, windows should keep the multiple functions, like outsight, entry of daylight, safeguarding, and ventilation, and at the same time, good insulation.

One of the challenges for windows is to optimize the heat flow depending on the season. If the building is heated and the outdoor temperature is cold, the window should retain heat in the building, minimize losses and let in as much solar radiation as possible. On the other hand, if the temperature inside the building is too hot and cooling is needed, the windows should keep out heat from the sun and if possible provide opportunities to remove heat from the building.

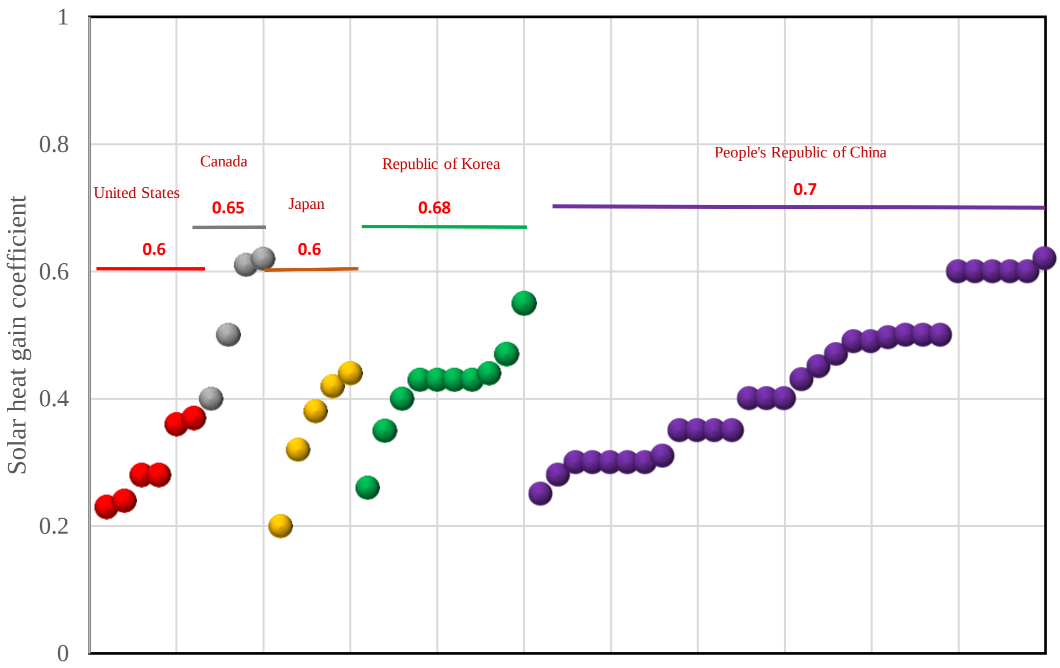


Figure 3-3 Window U-value of NZEB

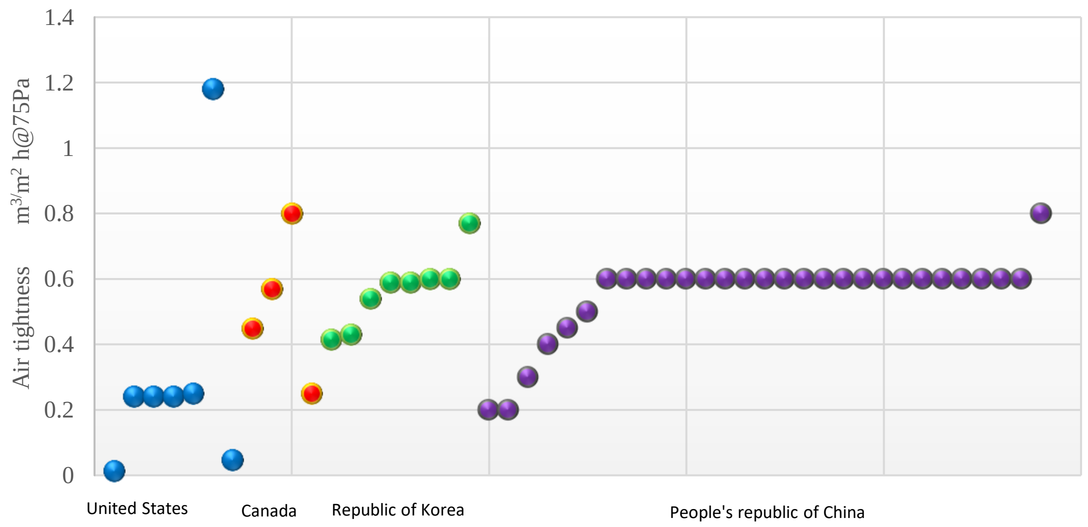


Figure 3-4 Window SHGC value of NZEB

The overall thermal performance of a building material or window is specified as thermal transmission (U value) and solar heat gain coefficient (SHGC). While the former is a measure of the rate at which heat passes through a component or structure when a temperature difference is maintained across the material; and the latter is the decimal expression of the percentage of incident solar radiation transmitted through glazing.

3.2.2 Passive strategy

Minimizing heating and cooling needs requires an integrated view of building design. Sunlight is free, and maximizing its benefits to reduce heating and lighting needs is part of an integrated design. Similarly, thermal mass, insulation, shading, reflective surfaces and natural ventilation can help minimize heat gains in summer and thus energy needs for cooling[21].

Table 3-1 Typical passive energy saving strategies [21]

Passive Strategies	Heating	Cooling	Lighting
Air tightness	●	●	
Ground Cooling		●	
Natural Ventilation		●	
Passive Solar Heat Gain	●		●
Site Vegetation		●	●
Skylight			●
Solar Tubes			●
Sun shading		●	●
Super insulation	●	●	
Thermal mass	●	●	
Thermal Zoning	●		

There are many available passive strategies, as well as numerous variations and hybrids derived from common designs. Generally, we can classify the passive strategies into four types according to the services: heating, cooling, ventilation, and lighting.

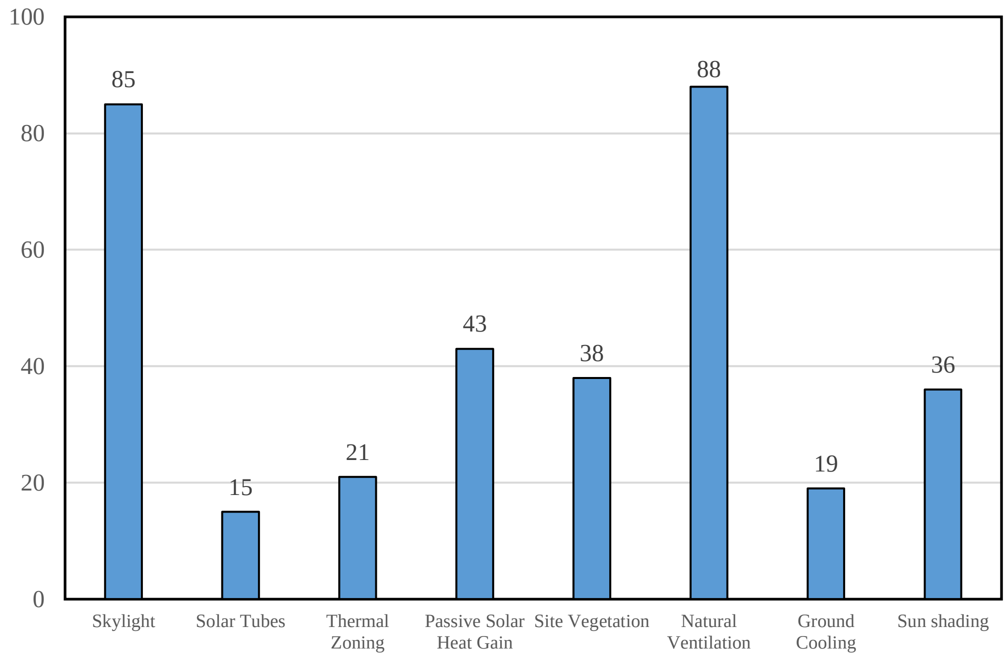


Figure 3-5 Passive Strategies adopted in projects

These design principles can significantly reduce heating and cooling loads at modest additional cost when constructing a new building.

For NZEB, passive strategies cannot be effectively integrated and must maximize combine architecture design, take very advantage of the building shape.

3.2.2.1 Passive heating

Thermal zoning

Thermal zoning is an important concept in HVAC system design, it is also the same vital in passive house design because a building will have a variety of thermal load and thermal need within the building, especially when the building is at a large enough scale.

Considering Thermal zoning meshing during NZEB design is an effective method of reducing heating/cooling energy demand. It should be adopted at the very beginning, even in the architectural plan. It can impact the program of the building and the use of passive design strategies.

Passive solar heat gain

Passive solar heating is one of several design approaches collectively called passive solar design. When combined properly, these strategies can contribute to the heating, cooling, and daylighting of nearly any building. The types of buildings that benefit from the application of passive solar heating range from barracks to large maintenance facilities.

Typically, passive solar heating involves:

- The collection of solar energy through properly-oriented, near equatorial facing windows.
- The storage of this energy in "thermal mass," comprised of building materials with high heat capacity such as concrete slabs, brick walls, or tile floors.
- The natural distribution of the stored solar energy back to the living space, when required, through the mechanisms of natural convection and radiation.
- Window specifications to allow higher solar heat gain coefficient in south glazing.

Passive solar heating systems do not have a high initial cost or long-term payback period, both of which are common with many active solar heating systems. Increased user comfort is another benefit to passive solar heating. If properly designed, passive solar buildings are bright and sunny and in tune with the nuances of climate and nature. As a result, there are fewer fluctuations in temperature, resulting in a higher degree of temperature stability and thermal comfort.

Thermal mass

The building thermal mass provides some energy storage capacity by allowing moderate temperature fluctuations—the so-called passive energy storage. Trombe wall, together with many other ventilation functional walls are good application of thermal mass.

3.2.2.2 Passive cooling

When mentioning passive cooling, the most common way is to prevent solar heat entering the building construction, such as sun shading and ground cooling. Among the 100 best practices, 100% of tropical area located projects adopted sun shading and only 6 projects that located in severe cold regions didn’t have sun shading design.

Comparing to sun shading, ground cooling have a restriction on building scale. Among the 100 best practices, 19 small (under 500 m^2) or middle scale (under 2000 m^2) projects adopted ground cooling as passive cooling strategy.

3.2.2.3 Passive lighting

Daylighting design begins by understanding the lighting needs and the local conditions. Besides the passive solar heat design, passive lighting is another factor that for architecture to considerate. An innovative daylighting technology is now gradually adopted in NZEB projects worldwide---Solar tube (or sun tunnel). During the investigation, 15 projects adopted this application, the further widely application may be restricted by the expensive cost.

Nearly Zero Energy Building in China Academy of Building Research

The Nearly Zero Energy Building in China Academy of Building Research (CABR) is located in Beijing, China, which was completed in July 2015. This building adhered to the design principle of "passive building, proactive optimization, economic and pragmatic". An ambitious annual energy consumption goal of 25 kWh/(m^2a) (including heating, cooling and lighting energy) was set during the design phase without compromise of building function and indoor environment quality. The demonstration project integrated best available building energy conservation technologies, striving to create a signature NZEB project and establishing the foundation for the development of China's NZEB standard.

Figure 3-6 Solar tube adopted in NZEB China Academy of Building Research

A Solar tube combined with auto-shading window system is installed in a conference room in 4th floor. Research regarding linkage control methodology and mechanism of solar tube and artificial lighting is carried out in this room. Approximately 500 lux lights could be achieved on the surface of the table (Figure 3-6) in sunny days by measurement. With the combination of solar tube and artificial lighting, about 20% light energy saving could be achievable.

3.3 Active approaches

If we take the passive approaches as the foundation for heating, cooling, ventilation, and lighting for a NZEB, then the active approaches are the security and necessity leading the building towards net zero. It is a combination between the design of passive strategies and renewable energy systems.

The experience with zero energy buildings shows that all energy uses in building must be examined and dry running to see if it has been reduced at the maximum extent. And the first step is to determine how energy will be used in the building, how many appliances will be set in the building. By analyzing the energy end use, it is not hard to see that energy efficient appliances is critical for paring down building energy demand.

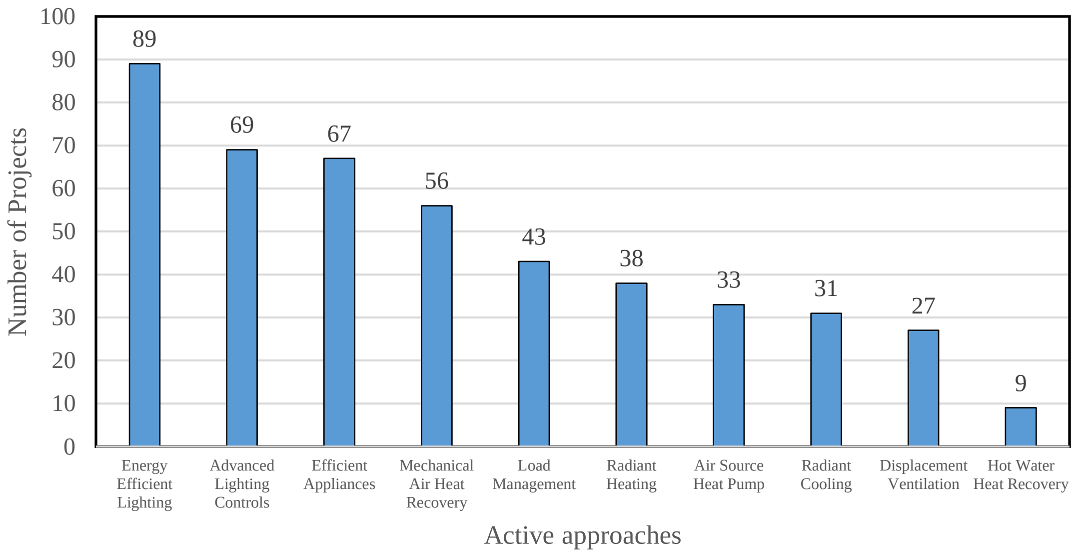


Figure 3-7 Active Strategies adopted in projects

3.3.1 Heating and cooling source

Energy consumption for space heating and cooling accounts for over half of the total building energy use. For NZEB, this part of energy can be reduced to 15 kWh/(m^{2}a) with high efficient heating and cooling systems. The most used heating/cooling systems that applied in the 100 investigated projects can be summarized as follows:

Boiler

The efficiency of traditional boilers is usually not higher than 80%. For NZEB projects, condensing boilers and pellet boilers are the two kinds of most used boilers.

(1) condensing boiler

Condensing boilers are water heaters fueled by gas or oil. They achieve high efficiency (typically greater than 90% on the higher heating value) by condensing water vapor in the exhaust gases and so recovering its latent heat of vaporization, which would otherwise have been wasted. This condensed vapors leaves the system in liquid form, via a drain.

【Best Practice】Xingfubao Passive Building

The Xingfubao Passive Pilot project is located in Urumqi City in north-west China which covers a treated floor area of 4317 m^2. Adopting high performance insulation and high air tightness, the annual heating demand of Xingfubao was reduced to 15 kWh/m^2. The condensing boiler is taken as the auxiliary heating system that can provide

Figure 3-8 The Xingfubao Passive Project

(2) Pellet heater/boiler

The pellet heater is a boiler of stove that burns compressed wood or biomass pellets to create a source of heat for residential and sometimes industrial spaces. By steadily feeding fuel from a storage container (hopper) into a burn pot area, it produces a constant flame that requires little to no physical adjustments. Today's central heating systems operated with wood pellets as a renewable energy source can reach an efficiency factor of more than 90%.

【Best Practice】Zero Carbon Green Home

Zero Carbon Green Home (ZCGH) is one of the zero energy building pilot projects in Korea. With the integration of passive and active design, ZCGH was able to achieve its goal of 87% reduction in heating energy consumption and 85% reduction in electricity consumption, which resulted in 82% savings in annual heating costs and 91% savings in electricity costs[22].

Figure 3-9 Zero Carbon Green Home (ZCGH), Republic of Korea

In order to supply space and water heating respectively for all 15 units in the building, two 50kW wood pellet boilers were installed. The wood pellets, with a calorific power of 5.2 kWh/kg, are considered CO_2 free. Up to two tons of wood pellets can be stored, and they are supplied through an automatic transportation feeder, which is able to provide a maximum consumption of 12 kg per hour. Indoor space heating is provided through underfloor heating. This system is only 1/5 the capacity of conventional apartment buildings.

Figure 3-10 Pellet boiler and storage in ZCGH[22]

Heat pump

Heat pumps are a particularly important technology for NZEB to reach net-zero energy status in an efficient way. The heat source/sink can be the air or the ground, or the water. Among the 100 best practices, 18 projects adopted air source heat pump, 23 projects adopted ground source heat pump, and 8 projects adopted water source heat pump.

【Best Practice】EcoTerra house

EcoTerra[23] is a two-story, two-bedroom, net-zero energy house located near Montreal in the rural town of Eastman, Quebec, Canada (Figure 3-11) with a heated floor area of 211 m^2. It is the first of 15 demonstration houses that was selected to be built through a competition under the Canada Mortgage and Housing Corporation (CMHC) Equilibrium Healthy Housing Initiative. EcoTerra™ was designed with a number of innovative technologies including a building-integrated photovoltaic system with thermal energy recovery and a hollow-core slab in the basement for thermal storage, passive solar design and a ground source heat pump. The local climate there is characterized by cold sunny winters and warm humid summers with moderate daily temperature swings. Passive solar design is maximized with the south-facing window-to-wall ratio of about 40%. Several fixed and movable shading devices were installed to help control unwanted solar gains particularly in the summer and shoulder seasons. The southern zone of the house's interior has concrete floor and knee walls on the main level and basement to provide thermally massive surfaces to regulate high levels of solar gains to prevent large temperature swings. EcoTerra has a 55 m^2 building-integrated photovoltaic/ thermal (BIPV/T) collector on the upper part of the roof with a total PV array peak capacity of 2.8 kW. The heated air from the BIPV/T roof was designed for three possible uses: 1) space heating by charging the ventilated concrete slab in the basement, 2) pre-heating domestic hot water using an air-to-water heat exchanger, and 3) drying clothes in a conventional clothes dryer that was modified to receive heated air in fan mode without electric heating.

To supplement the heating contribution from the passive solar heat gains and the BIPV/T system, the EcoTerra house includes a two-stage ground-source heat pump with an 11.1 kW thermal output capacity. The coefficient of performance (COP) of the GSHP was measured to be 3.5-4.0.

Although ÉcoTerra™ did not reach net-zero energy consumption, it consumes only 26.8% of the energy of a typical Canadian home and had an energy density of only 18.1% of the national average. ÉcoTerra™ uses only 8.9% of the heating energy per unit area of a typical Canadian home. This is primarily due to the significant effort put into the passive solar design of the house, but is also due to the contribution of the ground source heat pump and thermal energy collected by the BIPV/T roof.

Figure 3-11 The Eco Terra House. Canada

For now, more efficient heating/cooling equipment are available and becoming more and more cost-efficient. Table 3-2 gives some of the heating technologies together with their cost and efficiencies.

Table 3-2 Existing heating technologies together with their cost and efficiencies[21]

category	efficiency	Typical capital cost	Fuels	Operating cost
Conventional boilers	60-84	Low-medium	oil, natural gas	medium-high
Condensing boilers	85-97	Medium	oil, natural gas	medium-high
Pellet Boiler	75-85	Low-medium	Biomass	Low-medium
Masonry heaters	80-90	Medium	Biomass	Low-medium
Heat Pump (electricity)	200-600	Low-medium	Electricity	Low-medium
Heat Pump (gas driven)	120-200	medium-high	Gaseous fuels	Low-medium
Sorption Chillers	70-180	Medium	Natural gas, solar	medium-high
Solar thermal	100	Low - high	Solar	Low-medium

3.3.2 HVAC system

Radiant technology

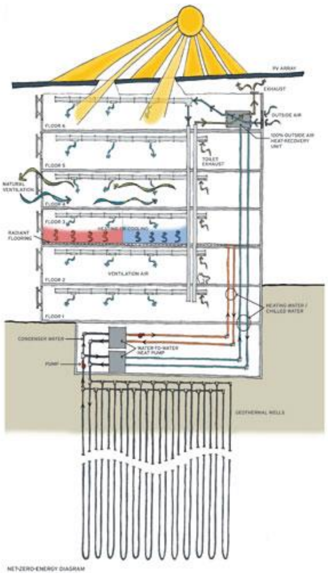
Radiant heating and cooling systems have been successfully used for nearly 30 years. According to the existing research, the radiant heating and cooling can offer lower energy consumption than conventional heating and cooling systems. Much of the energy savings is also attributed to the lower amount of energy required to pump water as opposed to distribute air with fans. By coupling the system with building mass, radiant cooling can shift some cooling to off-peak night time hours. Radiant cooling appears to have lower first costs [24] and lifecycle costs compared to conventional systems. Lower first costs are largely attributed to integration with structure and design elements, while lower life cycle costs result from decreased maintenance. However, a recent study on comparison of VAV reheat versus active chilled beams & DOAS challenged the claims of lower first cost due to added cost of piping [25].

【BEST PRACTICE】The Bullitt Center

The Bullitt Center is a 4,800 m^2 treated floor area commercial building located in Capitol Hill, Seattle, United States. (Figure 3-12).

Figure 3-12 The Bullitt Center, United States

The high efficient ground-source heat pump and in-floor radiant system heat the building extremely efficiently. Five heat pumps converts 11°C water from underground tubes to 35°C for heating the building with radiant heat system (Figure 3-13).



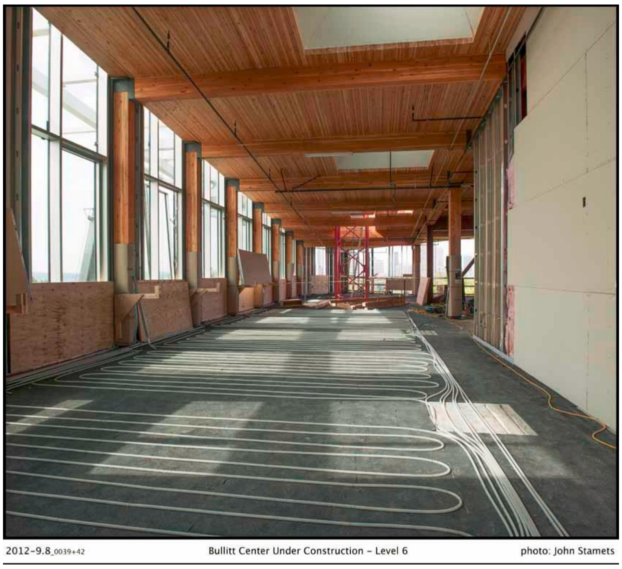


Figure 3-13 The high efficiency GSHP and in-floor radiant system in Bullitt Center

Displacement ventilation

Displacement ventilation is a room air distribution strategy where conditioned outdoor air is supplied at a low velocity from air supply diffusers located near floor level and extracted above the occupied zone, usually at ceiling height.

【Best Practice】The Seoul Energy Dream Center

The Seoul Energy Dream Center is located in Sangam-dong, Seoul, Republic of Korea, with treated floor area 3762 m^2. The building and its diamond-shaped architecture aims to teach citizen the importance of energy savings, sustainable architecture and center for renewable energy (Figure 3-14).

Figure 3-14 Seoul Energy Dream Center. Republic of Korea

Displacement ventilation is considered as an energy saving approach compared to standard mixing ventilation, especially for high inner space building. However, this may also a cause of discomfort due to the large vertical temperature gradient and drafts. The three-story building structure extends upwards and outwards at a 45 degree rotation, topped off by a square roof. Wedge-shaped roof projections are mounted along the façades at an upward tilt – helping increase the upper air flow of inner space, thus to eliminate discomfort.

Mechanical Air heat recovery

Mechanical Air heat recovery is an energy recovery ventilation system using equipment known as a heat recovery ventilator, heat exchanger, air exchanger, or air-to-air heat exchanger which employs a cross flow or counter-flow heat exchanger (countercurrent heat exchange) between the inbound and outbound air flow. HRV provides fresh air and improved climate control, while also saving energy by reducing heating (and cooling) requirements for many applications including vehicles.

【Best Practice】Shenyang Jianzhu University Sino-German Passive House

Shenyang Jianzhu University Sino-German Passive House is the first self-designed and built with three star green building. It is also the first Net Zero Energy demonstration building in Liaoning Province in China (Figure 3-15).

Figure 3-15 Shenyang Jianzhu University Sino-German Passive House. China

The ground cooling system together with the mechanical air heat recovery system save 1600 kWh electricity for air condition with the efficiency at 72% (Figure 3-16).

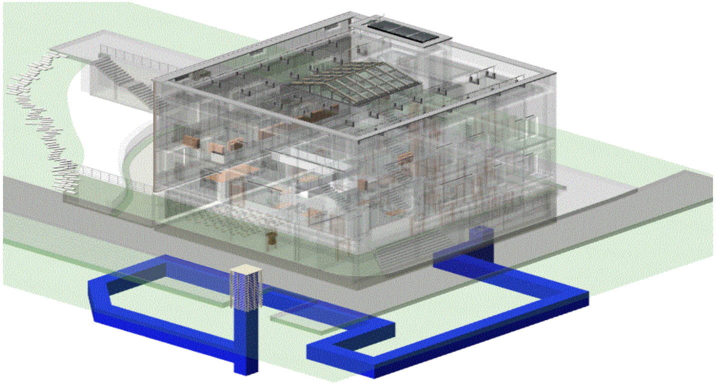


Figure 3-16 The ground cooling system together with the mechanical air heat recovery system

3.4 Lighting

Lighting becomes a major energy consumer after the reduction of heating and cooling demand in NZEB. The good news is that through improved use of natural lighting and adoption of highly efficient lamp technologies, the final power consumption for lighting can be decreased to a very low level and still has significant potential a lower one.

One of the advantages of energy efficiency improvement for lighting is that it is the easiest approach to achieve by renewable energy. Among the 100 best practices, nearly half of the project can solve the lighting energy consumption by photovoltaic.

Another efficient way to achieve highly efficient lighting is the solar tube which is nowadays considered to be modern devices that used at residential or public buildings. Solar tube are easily installed and can provide strong natural light during the day with their special light capturing mirrors and lenses. They can intensify light even with clouds or placement in less than optimum locations.

The nearly zero energy building (NZEB) at the China Academy of Building Research (CABR) is located in Beijing, China with the design principle of "passive building, proactive optimization, economic and pragmatic". The power provided by PV system goes to serve public area lighting firstly if required, and more for the internet. (Figure

3-17).

Figure 3-17 PV panel system serves public area lighting

3.5 Advanced control

Advanced control for NZEB here refers to the load management control system and the lighting system. Load management, also known as demand side management (DSM), is the process of balancing the supply of electricity, together with other mechanical systems on the network with the electrical load by adjusting or controlling the load rather than the power station output. This can be achieved by direct intervention of the utility in real time.

A lighting control system is an intelligent network-based lighting control solution that incorporates communication between various system inputs and outputs related to lighting control with the use of one or more central computing devices. Lighting control systems are widely used on both indoor and outdoor lighting of commercial, industrial, and residential spaces. Lighting control systems serve to provide the right amount of light where and when it is needed.

3.5.1 Energy system control

By achieving a Minuscule heating and cooling load and pleasant indoor environment, the Energy system turns to be hot research topic in the passive house or nearly zero energy buildings. Load management, also known as demand side management (DSM), is the process of balancing the supply of electricity on the network with the electrical load by adjusting or controlling the load rather than the power station output. Load management allows utilities to reduce demand for electricity during peak usage times.

The design of BIPV and Solar thermal, together with other renewable energy system application should pay more attention to balance the peak load.

CABR NZEB Energy system design and operation is an exploration of integrated design and is expected to give an effective solution of energy system design for nearly zero energy buildings in China. The integrated energy system requires more intelligent load management and the application of Building Automation system (BAS[26]) shows a successful example in building energy management system (Figure 3-18).

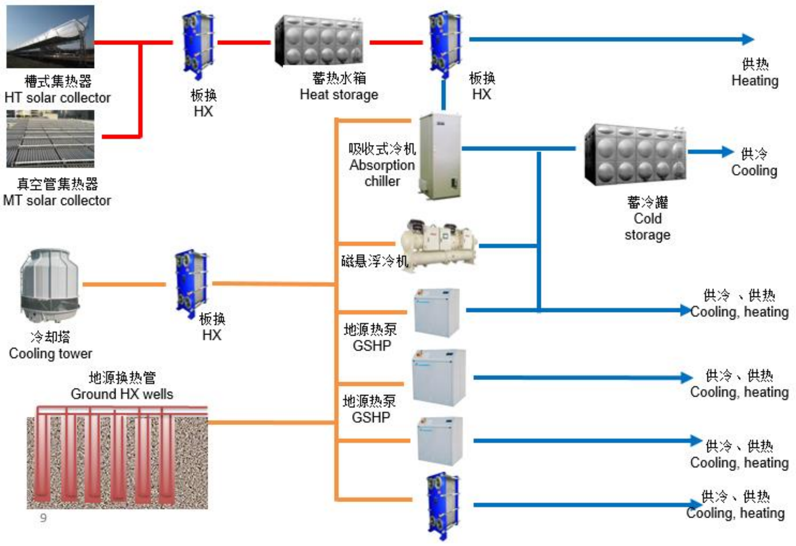


Figure 3-18 Integrated energy system

3.5.2 Lighting system control

When talking about advanced lighting control technology, Power over Ethernet (POE) is considered to be an efficient option for saving power consumption for lighting.

One of the successful application of POE in lighting control is the lighting system in CABR. LED and fluorescent lamps are installed in different floors, and two control brand with several control methodologies are applied in different floors and different lamps. Power over Ethernet (POE) with Led is applied and tested in one office room in the fourth floor, which in a connected lighting system, every luminaire is directly connected to and uniquely identified within a building' IT network, allowing system managers to monitor, manage and maintain individual light points via lighting management software. This system is the second application of POE in Asia region, which shows great research value for application of Direct Current in the lighting system (Figure 3-19).

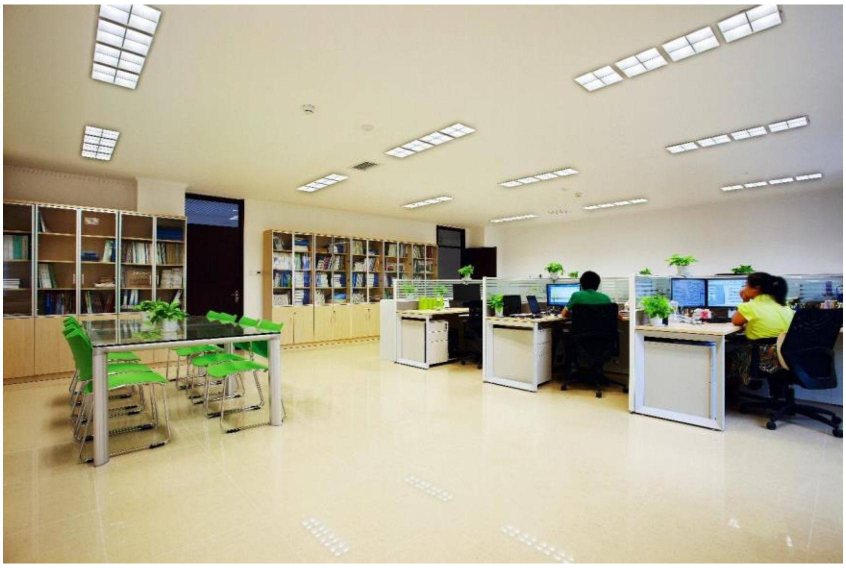


Figure 3-19 Lighting Control System adopted in NZEB in China Academy of Building Research

3.6 Technical Roadmap for NZEB

Among the best practices that collected, each economy owns their own characteristics of technological development. Take Japan for example, the fashionable passive and active measures can be concluded as follows [42]:

Fashionable passive measures were seen in the best practices as belows;

- Natural ventilation, Night purge
- Solar shading devices
- Daylight utilization
- Earth-to-air heat exchanger
- Others

Fashionable active measures were seen in the best practices as belows;

- LED lighting
- Task & Ambient Lighting / HVAC system
- High efficiency heat pump module chiller

- Ground heat source heat pump
- Radiation H/C system (Ductless system)
- Large temperature difference water supply
- Fresh air volume control by CO_2 concentration
- Separate sensible & latent heat HVAC system
- Desiccant HVAC system
- TES, Energy Management, Visualization and others

Renewable energy sources were;

- The most popular renewable energy source in these practices is PV
- Biomass power generation like wooden chips, pellets

Finally, nZEB technologies should be introduced while the heat load characteristic of nZEB is considering as shown belows;

- Decrease of Heat load
    - ✓ Down sizing of equipment capacity
    - ✓ Enlarge portion of Energy for heat transfer or standby
- Increase partial load ratio
    - ✓ Apply high efficiency equipment (ex. Heat pump)
    - ✓ Apply thermal energy storage
    - ✓ Apply renewable energy source (ex. Ground-source)
- Enlarge portion of fresh air load
    - ✓ Reduce fresh air load and handling it high efficiency
- Smaller sensible heat factor
    - ✓ Apply Separate sensible & latent heat HVAC system

- ✓ Desiccant with solar thermal energy

Proper technical approaches are critical to realize NZEB. The technical road map for NZEB can be divided into 3 steps: By reasonable passive design, including high performance envelope, good airtightness, and passive heat gains, the building energy consumption can be reduced by at least 30% compared to average buildings; By appropriate active approaches, including high efficiency appliances, the building energy consumption can be reduced by 20% and reach ultra-low energy building; By replace 10-30% of the energy with renewable energy such as from building-integrated photovoltaics, the building can reach Nearly Zero Energy Building status; When the annual building consumption can be met with renewable energy, it becomes a Net Zero Energy Building.

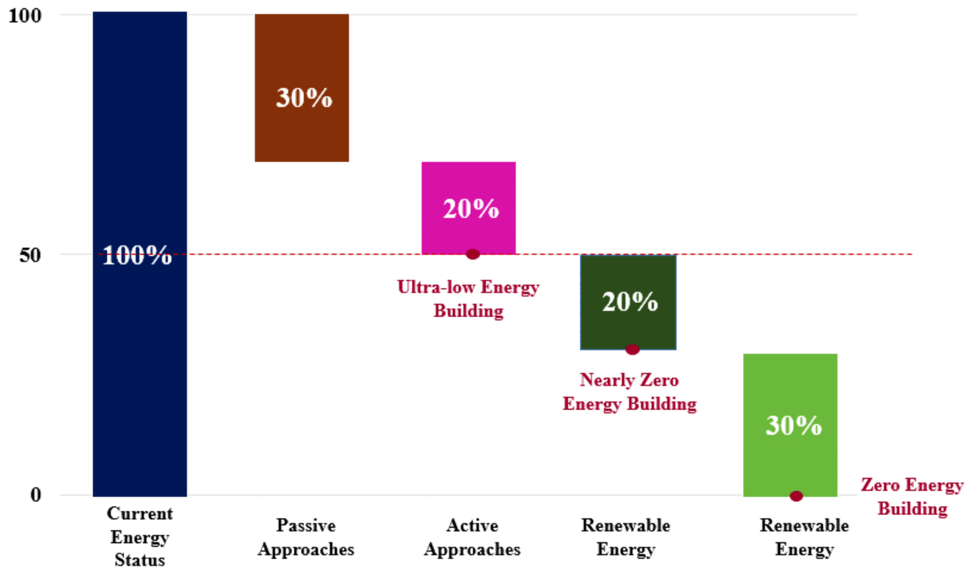


Figure 3-20 Technical roadmap for Zero Energy Building in China

Chapter 4 Conclusion

1. Energy saving target. According to the declaration on 2013 and 2014--- To reduce APEC's aggregate energy intensity by 45% from 2005 levels by 2035, and this have received various consensus among each economy. Many international organizations have shown their pursuit of higher building energy saving target---To realize Nearly Zero Energy Building of Zero Energy building before 2030. This will give strong support to UN and APEC 2035 energy intensity target.

2. Policies show the ambitious target of governments. According to the "13th Five Year Work Plan" issued by China State Council, no less than 10 million square meters of ultra-low energy building and NZEB demonstrations will be constructed in China. As for US government, long term bold goal and mid-term action plan are issued by federal government and states: for federal buildings, as of 2020, all planning for new Federal buildings requires design specifications that achieve Zero-Net-Energy use by 2030; for commercial buildings and residential buildings, marketable net zero energy homes by the year 2020 and commercial net zero energy buildings at low incremental cost by the year 2025.

3. Building codes and standards. Energy codes and standards play a vital role by setting minimum requirements for energy-efficient design and construction. ASHRAE 90.1 and related standards works as the Model Code as US building energy codes, together with Title 24 of California, all have a clear goal to achieve NZE step by step. China published the Passive Ultra-low Energy Green Building Technical Guidance in 2016 and the National Standard Nearly Zero Energy Building Standard will be come into forth in 2019. Together with other evaluation standards, the specific codes and standards on NZEB will become an inevitable trend.

4. Incentives and subsidies. As the most effective way to promote NZEB, Korean and Chinese government promulgated a series of incentives, such as building deregulation, proper tax deduction, housing provident fund loans and many other project subsidies, thus to help cover the increasing cost of NZEB construction and realize the industrialization of ZEB component promotion.

5. Proper technical approaches are critical to realize NZEB. The technical road map for NZEB can be divided into 3 steps: By reasonable passive design, including high performance envelope, good airtightness, and passive heat gains, the building energy

consumption can be cut 30% off; By appropriate active approaches, including high efficiency appliances, the building energy consumption can be cut 20% off and reach ultra-low energy building; Replace 10-30% of the energy with renewable energy, the building can reach NZEB status; When the annual building consumption can be meet with renewable energy, it becomes a Net Zero Energy Building.

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Appendix A

Workshop of APEC Nearly /Net Zero Energy Building Roadmap responding to COP21

5th Workshop of APEC Nearly/Net Zero Energy Program

December 2017

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Workshop of APEC Nearly /Net Zero Energy Building Roadmap responding to COP21

Overview

The workshop is a continuation of previous workshops held under EWG 02 2015A and EWG 03 2013A. The three days' workshop invited 37 participants that from 11 economies to take part in this workshop.

The previous workshop provides an opportunity to facilitate connections among policymakers, industry leaders, and researchers in APEC Economies along with allowing stakeholders to exchange information and share experience on specific policy initiatives that promote NZEB development.

The workshop objective is:

- Share the latest policy progress of NZEB, what is the goal in each economies responding to COP 21 and is there any goal on building or NZEB was set up. The comprehensive analysis on the building energy reduction goals between UN and APEC 2035 energy intensity target will be taken as the basis and a medium to long-term goal will be proposed to support NZEB development throughout APEC regions.
- Share the latest research outcome and best practice information of NZEB
- The policy and technology priority list in each economy in NZEB. The collection of detailed and latest information on NZEB policies, promoting programs, best practices, and technical roadmaps will finally form the APEC NZEB Policy Priority List. By integrating the existed progress among APEC economies, this program will harmonize the Nearly/Net Zero Energy Roadmap within the APEC region, provide accessible methods and target to achieve NZEB in all climatic zones, prioritize a list of recommendations for APEC economies to fast track the goal of NZEB.
- What is the suggestion of APEC goal on NZEB and what work could happen between members through APEC to contribute towards achievement such a goal.

Symposium Program

Thursday September 4, 2017   Location: EV 2.260

Economy Overview

08:00-09:00	Workshop Registration	
09:00-09:05	Welcome Speech	Prof XU Wei. China Academy of Building Research
09:05-09:20	Self-Introduction	Chair: Mr ZHANG Shicong. China Academy of Building Research
09:20-09:30	Previous Projects Report and Workshop arrangements explanation	
	Session 1 Economy Overview Time: 09:30-10:30 Chair:Mr ZHANG Shicong. China Academy of Building Research	
1-1	Nearly Zero Energy Building Overview & Updates of China	Prof XU Wei. China Academy of Building Research. P.R. China
1-2	Zero Energy Building Overview & Updates in USA	Mr Sameul RASHKIN Chief Architect, Building Technologies Office United States Department of Energy
1-3	The Journey to Date of Nearly/Net Zero Energy Buildings in Korea	Prof Dongwoo Cho. Korea Institute of Civil engineering and Building Technology. Korea

1-4	Australia's investigations into Near/Net Zero Energy Buildings	Director Jodie Pipkorn. Residential buildings team. Energy Productivity Branch Department of the Environment and Energy. Australia
Group Photo and Morning Coffee Break 10:30-11:00		
Session 2 Economy overview Time: 11:00-12:30 Chair:Prof Masaya Okumiya. Nagoya University		
2-1	Overview of recent research and developments in net zero energy buildings in Canada	Prof Andreas Athienitis. Concordia University, Canada (Presentation by Skype. 11am in Hawaii is 5pm in Montreal Monday)
2-2	Activities to realize ZEB and progress of implementation of ZEB in Japan	Prof Masaya Okumiya. Nagoya University. Japan
2-3	Energy Efficiency in Buildings in Chile: Net Zero Energy Buildings Future	Ms. Paula Olivares. The Ministry of Housing. Chile
2-4	Latest R&D Progress of ZEB in Russian federation	Ms Nelly Segisova Ministry of Energy. Russian

Midnoon Coffee Break Lunch (Self-funded) 12:30-13:30
S3 Discussion Session Policy priority to achieve ZEB in each economy All participants will be in Group A and B. TBD 13:30-15:00 Close of Day 1

Thursday September 5, 2017 Location: EV 2.260

Latest Progress

Session 4 Latest Progress 09:00-10:30 Chair: Chuck Kutscher, Ph.D., P.E.Director, Buildings and Thermal Systems Center. National Renewable Energy Laboratory		
4-1	Latest R&D Progress of ZEB in USA	Chuck Kutscher, Ph.D., P.E. Director, Buildings and Thermal Systems Center National Renewable Energy Laboratory
4-2	ZEBs meet Ground Source Heat Pumps in Japan	Prof. Katsunori Nagano Hokkaido University. Japan

4-3	APEC long term building energy modelling	Senior Researcher. Martin Brown Santirso. Asia Pacific Energy Research Center
4-4	Emerging Cooling Technologies in Zero Energy Building Applications	Prof Christopher Yu-Hang CHAO. The Hong Kong University of Science and Technology
Coffee Break: 10:30-11:00		
S 5 Latest Progress 11:00-12:30 Chair: Prof Usha Iyer Raniga. RMIT. Australia		
5-1	NZEB in severe cold and hot climate	Professor Yanfeng Liu Xi`an University of Architecture and Technology
5-2	Benchmarking Australia for NZEB practices' against trends in Asia	Prof Usha Iyer Raniga. RMIT. Australia
5-3	Solar Energy Systems for NZEBs	Director Zhu Li. Asia Pacific Sustainable Energy Center.
5-4	California movements to NZEB Title 24	Manager. Carolyn Szum Lawrence Berkeley National Laboratory. United States.
Midnoon Coffee Break		

Lunch (Self-funded) 12:30-13:30
S6 Discussion Session Technology Priority to achieve ZEB 13:30-15:00   GALA DINNER Funded by Energy Foundation China Low Carbon City Program Dinner Location: Lurline Lawn 19:00-21:00 Close of Day 2

Thursday September 6, 2017 Location: EV 2.260

Best Practices & Certification

<table>
<tr><td colspan="3">Session 7 Best Practices & Certification

09:00-10:30

Chair: Director Brad Liljequist. International Living Future Institute</td></tr>
<tr><td>7-1</td><td>The Power of Zero: Learning From the World’s Leading Net Zero Energy Buildings</td><td>Director Brad Liljequist. International Living Future Institute</td></tr>
<tr><td>7-2</td><td>Canada’s first institutional solar NZEB: Varennes library</td><td>Associate Professor. Ge Hua

Concordia University. Canada</td></tr>
<tr><td>7-3</td><td>Updates of best practices and nZEB technologies in Japan</td><td>Associate Prof. Gyuyoung YOON. Nagoya City University</td></tr>
<tr><td>7-4</td><td>First 19 Nearly Zero Energy Building certification projects in China</td><td>Prof Sun Zhifeng. China Academy of Building Research</td></tr>
<tr><td colspan="3">Coffee Break

10:30-11:00</td></tr>
<tr><td colspan="3">S 8 World Trend

Subsidy & Financial Support

11:00-12:30

Chair:

Director Kevin Mo. Paulson Institute</td></tr>
</table>

8-1	Getting to Zero	Prof Edward Mazria. Architecture 2030. USA. (By Skype，11am on Wednesday in Hawaii, is 3pm in Santa Fe, New Mexico)
8-2	From Thousands to billions Coordinated Action towards 100% Net Zero Carbon Buildings By 2050	Ms Victoria Burrows， Project Leader World Green Building Council (By Skype,11 hours' time difference between Hawaii and UK. 11:20 am Wednesday in Hawaii is 0:20 am in UK Thursday))
8-3	Green Financing and insurance in urbanization	Director Kevin Mo. Paulson Institute
8-4	Green Financing in building	Director Yao Yuan. Greenliving Fund
Coffee Break 12:30-13:00		
S 9: Report of S3 and S6 Discussion& Wrap up Chair: Mr ZHANG Shicong 13:00-13:30		
9-1	Team A Report of S 3 & S 6	Team A leader

9-2	Team B Report of S 3 & S 6	Team B leader
9-3	Final Wrap Up and next step	Dr ZHANG Shicong

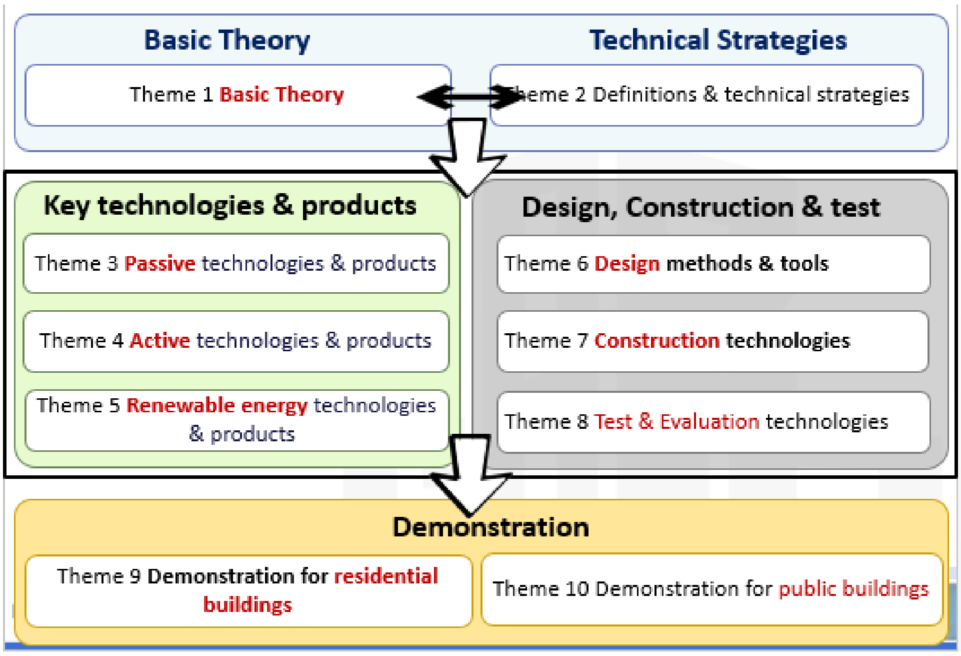
Key Points from Presentations

Session 1 Economy Overview

1-1 Nearly Zero Energy Building Overview & Updates of China

XU Wei, Ph.D., China Academy of Building Research. P.R. China

- MOHURD published 《13th Five Year Plan of Building Energy Efficiency and Green Building》 in February 2017
- The first pilot building came from UK and Germany in 2010 world Expo in Shanghai, and now nearly 100 best practices are completed
- Since 2010. MST and MoHURD supported CABR in various topics related with this topic, 3 of them are finished and 2 are on-going. Application of Renewable Energy Storage Technology in Low Energy Buildings, CABR Nearly zero energy building demonstration project, Study and Demon. Of Passive Ultra-low Energy Buildings for Different Climate Zones.
- CABR Nearly zero energy building demonstration project is the outcome of China-US Clean Energy Research Center 1.0
- The 13th Five-Year National Key R&D Plan Project Nearly-ZEB key strategies and technologies development 2017-2020 is ongoing



- Nearly Zero Energy Building Technology Guide is the first technical guidance that set specific Indoor Environmental Parameter and energy target.

  - The ministry decided to upgrade the guide to national standards. And the Nearly Zero Energy Building NATIONAL STANDARD was kicked off July last year.

  - China Passive Building Alliance was established in late 2014 and aiming at promoting ZEB

  - Since 2015. Professor Xu Wei proposed a “30-30-30” goal of NZEB in China that by the end of 2030, 30% of new construction should be NZEB and 30% of existing building should be retrofitted to NZEB and 30% of the building energy should from Renewables.

1-2 Zero Energy Building Overview & Updates in USA

Sameul RASHKIN, Chief Architect, Building Technologies Office United States Department of Energy

  - The goals of Building Technologies Office Multi-Year Program Plan, U.S. DOE is to reduce the residential space conditioning and water heating energy use by 40% from 2010 levels, thus to reduce EUI in residential buildings by 40% from 2010 levels.

- Risk Driver: Advanced Enclosure

  Outcome: +Insulation+ Windows+ Air Sealing

  Reality: > Code Rigor

- Zero = Risk Management, six complete systems: optimized enclosure, water protection, ensured comfort, indoor air quality, efficient comps, solar ready.

- ZEB can bring $150 Billion, 1 Million jobs, $100s Billion Property Tax Revenue.

- Substantial Uncertainty: Software Predictions, Occupant Impacts, External Forces

- Zero Energy Ready Home:
  High-performance home, so energy efficient, all or most annual energy consumption can be offset by renewable energy.

- NREL Research Support Facility: 50% less energy than current commercial codes, $0 extra capital cost, 10X more space (60%) vs. more energy use (6%)

1-3 The Journey to Date of Nearly/Net Zero Energy Buildings in Korea

Dongwoo Cho, Professor, Korea Institute of Civil engineering and Building Technology. Korea

- Target to reduce the greenhouse gas emission in Korea in building sector: Reducing 18.1% of GHG emission by 2030 compared to BAU

- U-value limit of building envelope according to climate area for all buildings

- Reinforcement of Design Criteria For Building Energy Saving

- Strategy for Pioneer Zero Energy Building Projects: Low-rise, High- rise, Town

- ZEB Certification System was started by Ministry of Land, Infrastructure and Transport and Ministry of Trade, Industry and Energy from January 2017.
- ZEB Certification in Korea Green Building Regulation is defined as more than 20% energy self-reliance rate and more than BER 1++ grade building.

1-4 Australia's investigations into Near/Net Zero Energy Buildings

Jodie Pipkorn, Director, Residential buildings team. Energy Productivity Branch Department of the Environment and Energy. Australia

- Much of the Australian building stock could be ZEBs, The number of new detached houses are expected to continue into the future.
- ZEBs could help meet Australia's international climate commitments – buildings built now will still be here in 2050.
- Australia has a range of climates, so may require different ZEB models. The NEPP brings together energy efficiency, energy market reform and climate policy

Session 2 Economy Overview

2-1 Overview of recent research and developments in net zero energy buildings in Canada

Andreas Athienitis, Professor, Concordia University, Canada

- The NSERC Solar Buildings Research Network (SBRN) has performed research and demonstration projects on technologically advanced solar buildings (2005-2011).
- Objective target for high performance buildings promotes an integrated approach to energy efficiency and renewable - path to net-zero.
- Major international trends in high performance buildings: 1) Adoption by engineering societies and developed economies of net-zero energy as a long

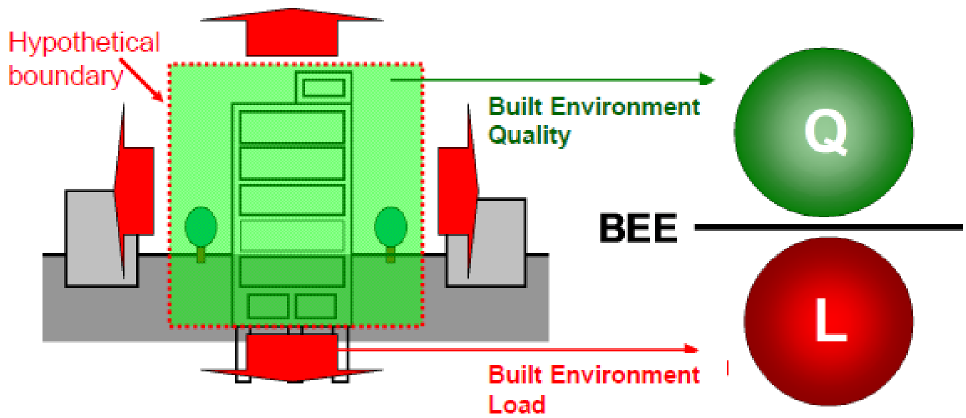
term goal (ASHRAE Vision 2020); 2) Measures to reduce and shift peak electricity demand from buildings, thus reducing the need to build new power plants; integrate with smart grids; resilience; 3) Steps to efficiently integrate new energy technologies such as controlled shading devices and solar systems

- BIPV – integration in EcoTerra
- Varennes Library – Canada's first institutional solar NZEB

2-2 Activities to realize ZEB and progress of implementation of ZEB in Japan

Masaya Okumiya, Professor, Nagoya University. Japan

- Industrial sector energy consumption has leveled off, but a significant increase in energy consumption has been observed in the commercial and residential subsectors (Building Sector).
- Act on the Improvement of Energy Consumption Performance of Buildings (Building Energy Efficiency Act)
- Approval of Compliance with Energy Efficiency Standards /Labeling System based on Article 36 of the Act
- Worldwide trend of building environmental performance assessment
- Comprehensive Assessment System for Built Environment Efficiency



2-3 Energy Efficiency in Buildings in Chile: Net Zero Energy Buildings Future

Paula Olivares, The Ministry of Housing. Chile

- The commitment announced at the signing of the Paris agreement during the Unite Nations General Assembly in New York on September 20, 2016 that 30% GHG over GDP/unit will be reduced by 2030.
- 20% of the energy consumption projected to 2025.
- 20% of the Non-Conventional renewable energy generated by 2025.
- Residential Thermal Regulation (Mandatory)---30% of heating energy demand will be cut

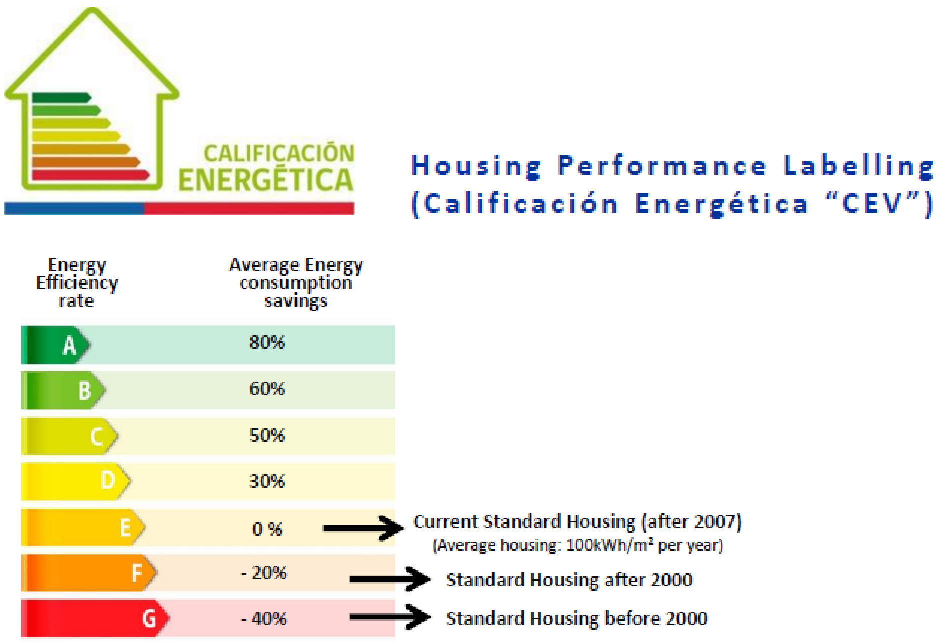
  1) New thermal zones, recognizing climate diversity.

  2) Increased requirements of envelope (walls, windows, ceilings and ventilated floors).

  3) Infiltrations, thermal bridges, condensation requirements.

  4) Incorporation of ventilation system.

- Housing Performance Labelling (Non mandatory).



- Sustainable Construction Standards for Housing (SCSH): Guide for best practices to improve the housing environmental performance, using objective and reliable criteria and defining sustainability parameters, for the design, construction and operation of new or renovated housing.

- Sustainable Housing Certification; Voluntary system of environmental certification for housing, based on SCSH, with responds to the reality and diversity of the nation

Session 4 Latest Progress

4-1 Latest R&D Progress of ZEB in USA

Chuck Kutscher, Ph.D., P.E., National Renewable Energy Laboratory

- NREL Research Support Facility: The Nation's Largest Net Zero Energy Office Building.
- Performance-Based Acquisition: 25 kBtu/SF-yr, $259/SF
- Technologies: Underfloor Ventilation, Radiant Ceilings, Operable Windows, Thermal Mass Wall, Daylighting importing
- NREL is DOE's Lead Lab for Building Energy Modeling. U.S. Electricity Consumed by Buildings: 74%
- Scaling Up to Zero Carbon Districts: The Next Step in Achieving Zero Carbon
- URBANopt: NREL's zero energy district modeling tool

4-2 ZEBs meet Ground Source Heat Pumps in Japan

Katsunori Nagano, Professor, Hokkaido University. Japan

- Japanese government (August, 2009) authorized that aerothermal, hydrothermal and ground thermal energy as the renewable energy source in a new energy law.
- Rusutsu village Children Care Center
- Prediction of the primary energy consumption of this children center buiding, contributions of GSHP heating system and the earth tube to reduce the primary energy consumption are 15.3% and 5.5 %, respectively.
- Operation results. Annual energy consumption for heating per unit of floor area is 22.7 kWh/(m^2a). Annual average SCOP was 3.35

4-3 APEC long term building energy modelling

Martin Brown, Senior Researcher, Asia Pacific Energy Research Center

- The APEC Energy Supply and Demand Outlook 7th Edition The content includes: 1) APEC demand and supply under business as usual to 2050; 2) APEC demand and supply under alternative scenarios; 3) Energy investment; 4) Raising APEC climate ambitions
- Building overall demand was estimated using a top down econometric approach based on GDP and population
- Moderate GDP growth in developed economies while emerging economies grow at a faster rate. Population growth slow in most economies and some decrease
- For residential buildings, energy demand decreases by 12% from 2015, and 16% compared with BAU
- Further measures for 2DS-----1) Low carbon energy; 2) Increase efficiency; 3) Reduce overall activity demand

4-4 Emerging Cooling Technologies in Zero Energy Building Applications

Christopher Yu-Hang CHAO. Professor, The Hong Kong University of Science and Technology

- Energy Indicators for Hong Kong: 1) High population density (compact city); 2) Service-oriented (few industries & manufacturing); 3) No oil refinery; 4) Extensive use of public transportation
- HK is under a sub-tropical climate -----1) heating is not required in winter; 2) Cooling is needed in both summer and winter (the major target), and consumes a large amount of energy
- Passive cooling systems are least expensive means of cooling which maximizes the efficiency of the building envelope minimizing use of mechanical devices.
- **Cooling/Smart Technologies**: a part of the target for achieving the Net Zero Energy Buildings together with many others!

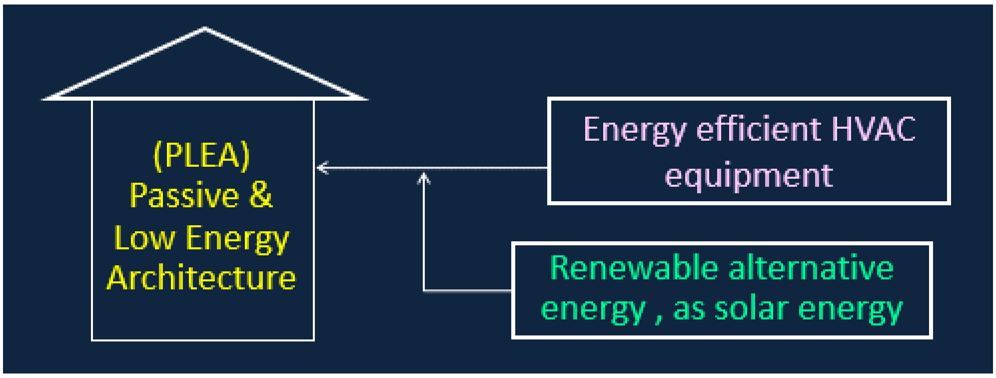
- **Indoor Environment Quality** should not be compromised!
- **Occupants' behavior in energy usage**!

Session 5　Latest Progress

5-1 Moving Towards NZEB with PLEA

LIU Jiaping, Professor, Xi`an University of Architecture and Technology

- LEA—Low energy architecture is familiars concept in all the school of Architecture in the world. LEA mostly refers to the architectural design is very good and the performance index of energy consumption of a design scheme is small.
- PLEA—passive and low energy architecture which probably is passive solar + LEA.
- NZEB—Net Zero energy buildings could be considered as
  LEB +　Active Solar (PV + Solar Heating)



- Case study in the cold climate zone--- *Yaodong* Dwellings, or *Yaodong*　Cave Dwellings.

5-2 Benchmarking Australia for NZEB practices' against trends in Asia

Usha Iyer Raniga, Professor, RMIT. Australia

- UN 10 YFP.
- Australia's emission goal is to reduce emissions to 26-28% on 2005 levels by 2030.
- Goal is to reduce emissions to 26-28% on 2005 levels by 2030.
- Lack of NZEB is not a hindrance

- Operational energy tracking is the only way to truly handle energy use
- Both residential and non-residential sectors need to be involved

5-3 Solar Energy Systems for NZEBs

Zhu Li, Director, Asia Pacific Sustainable Energy Center

- APSEC was established in the 11th APEC EMM in 2014 China Year.
- Under APEC mechanism, APSEC is directly guided by APEC Energy Working Group (EWG).
- The aim of APSEC is to promote energy technology transfer and cooperation through cities, implement demonstration project construction, and enhance internationalization level of cities of the Asia-Pacific region.
- Innovative Solar Energy Technologies in Tianjin University group.

  1) Dynamic Concentrating Solar Building Skin

  2) Optical performance simulation of LFMR
- Typical Demonstration Projects

5-4 California movements to NZEB Title 24

Carolyn Szum, Manager, Lawrence Berkeley National Laboratory. United States.

- NZEB Initiatives In the United States.
  1) The Energy Independence Security Act of 2007
  2) Executive Order 13693
  3) U.S. DOE’s Building America and Challenge Homes Programs
- **North American Movement to NZEB.** In 2015 there were 191 NZEB Verified and Emerging projects by New Buildings Institute (NBI). In 2016, there were 332 projects, for an increase of 74% in a single year!
- **NZEB Locations in North America.** The largest number of NZEB emerging and verified buildings in North America are in California. All new residential

construction will be zero net energy by 2020, all new commercial building achieve net zero energy goal by 2030.

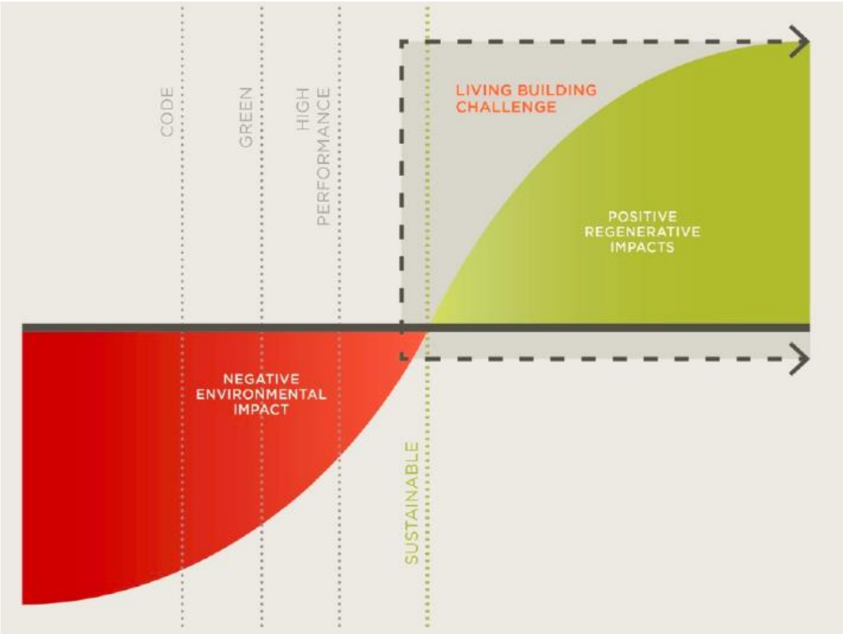
- California State Assembly Bill 32 (AB32), Global Warming Solutions Act of 2006
- California Public Utilities Commission (CPUC) "Big Bold Energy Efficiency Strategies (BBEES)"
- Title 24 2016 Standard-----commercial highlights and residential highlights, Financial Cost Considerations were adopted in California

Session7 Best Practices & Certification

7-1 The Power of Zero: Learning from the World's Leading Net Zero Energy Buildings

Brad Liljequist, Director, International Living Future Institute

- The Bullitt Center is aiming at creating an alternative narrative of deep solutions.



- RMI innovation center
- Omega Center
- Phipps Conservatory

- West Berkeley Public Library
- Hood River Middle School
- David Baker Zero Cottage
- Packard Foundation HQ
- DRP construction regional office

7-2 Canada's first institutional solar NZEB: Varennes library

Athienitis Andreas (Professor) and Ge Hua (Associate Professor), Concordia University. Canada

- The NSERC Solar Buildings Research Network (SBRN) and the successor network NSERC Smart Net-zero Energy Buildings Strategic Research Network have performed research and demonstration projects on technologically advanced solar and net-zero buildings (2005-2017).
- Partnership: NRCan CanmetENERGY, Concordia University, Stantec Inc., Martin Roy Associates

  Integrated Design Process (2011-2013)

  Construction: 2014-2015

  Officially opened: May 2015
- LEED gold certification.
- 110.5 kWp BIPV (part BIPV/T), Heat recovered on part of the array to supplement fresh air heating, 38° slope, oriented South to South-East
- 30% energy dedicated to lighting
  - 300-500 lx for office spaces and library reading [IESNA]
  - 200-500 lx for stacks
  - Current: schedule based, aiming 800 lx throughout
- 50-60% for space conditioning

Set-point limits relaxed -- allowing up to 26°C

Library building, runs on a schedule

Motorized windows open 10% of year for natural ventilation

Radiant slabs used to pre-charge

7-3 Updates of best practices and nZEB technologies in Japan

Gyuyoung YOON, Associate Professor, Nagoya City University

32 best practice in Japan were introduced and the relevant passive and active measures were discussed through the best practices.

Fashionable passive measures were seen in the best practices as belows;

- Natural ventilation, Night purge
- Solar shading devices
- Daylight utilization
- Earth-to-air heat exchanger
- Others

Fashionable active measures were seen in the best practices as belows;

- LED lighting
- Task & Ambient Lighting / HVAC system
- High efficiency heat pump module chiller
- Ground heat source heat pump
- Radiation H/C system (Ductless system)
- Large temperature difference water supply
- Fresh air volume control by CO_2 concentration
- Separate sensible & latent heat HVAC system
- Desiccant HVAC system

- TES, Energy Management, Visualization and others

Renewable energy sources were;

- The most popular renewable energy source in these practices is PV
- Biomass power generation like wooden chips, pellets

Finally, nZEB technologies should be introduced while the heat load characteristic of nZEB is considering as shown belows;

- Decrease of Heat load
  - ✓ Down sizing of equipment capacity
  - ✓ Enlarge portion of Energy for heat transfer or standby
- Increase partial load ratio
  - ✓ Apply high efficiency equipment (ex. Heat pump)
  - ✓ Apply thermal energy storage
  - ✓ Apply renewable energy source(ex. Ground-source)
- Enlarge portion of fresh air load
  - ✓ Reduce fresh air load and handling it high efficiency
- Smaller sensible heat factor
  - ✓ Apply Separate sensible & latent heat HVAC system
  - ✓ Desiccant with solar thermal energy

7-4 First 19 Nearly Zero Energy Building certification projects in China

Sun Zhifeng, Professor, China Academy of Building Research

- <Passive Ultra-low Energy Consumption Green Building Technical Guidance (Trial Implementation) (Residential Building)>Was Launched in November 2015..
- The first 19 cases are in 10 provinces and cities in China. 2 cases in Beijing, 4 cases in Shandong province. There are 4 cases in Hebei province too. In other ways of distributions, 6 cases are residential building and 9 cases are office buildings.
- Technology Application—Passive technology

  Air through tunnel

  Heat storage

  Green plant

  Passive heat gain

  Architectural Shading

  Natural ventilation

  Natural lighting
- Technology Application—Active technology

  Efficient lighting, Energy-efficient appliances and Heat recovery through ventilation have higher usage rate than other technologies.
- Technology Application—Renewable energy system

  The usage rate of Solar Energy and Ground Source Heat Pump is the highest among other renewable energy systems.
- Incremental Cost

  The incremental cost of public buildings is generally higher than that of residential buildings.

  The average incremental cost of residential buildings—700yuan/㎡

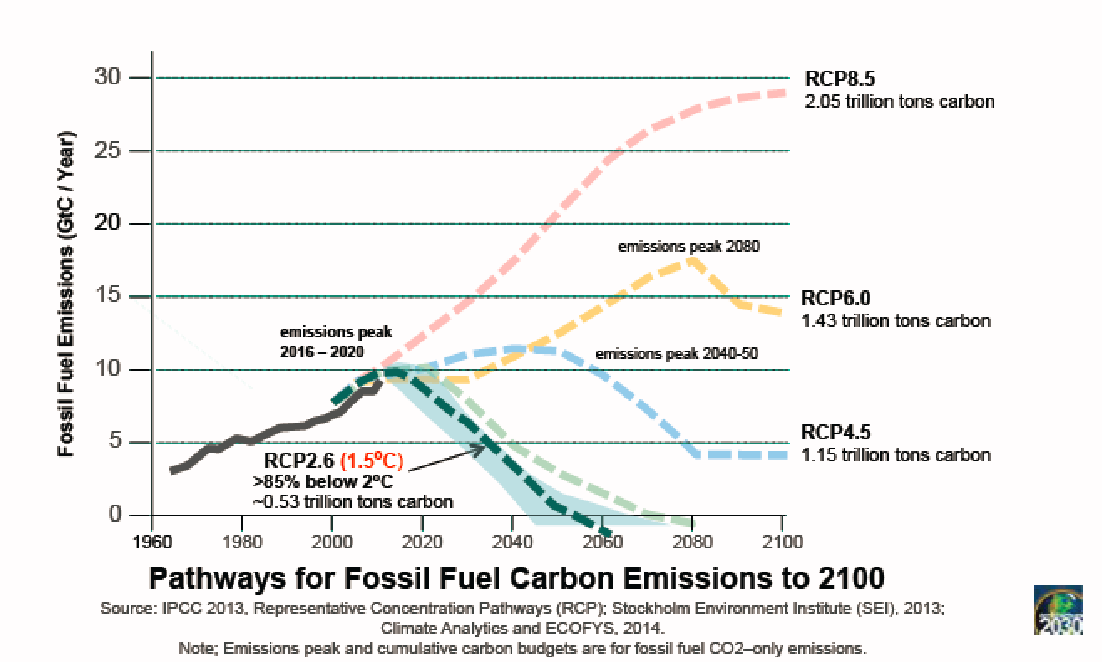
  The average incremental cost of public buildings ——1500yuan/㎡

Session 8 World Trend Subsidy & Financial Support

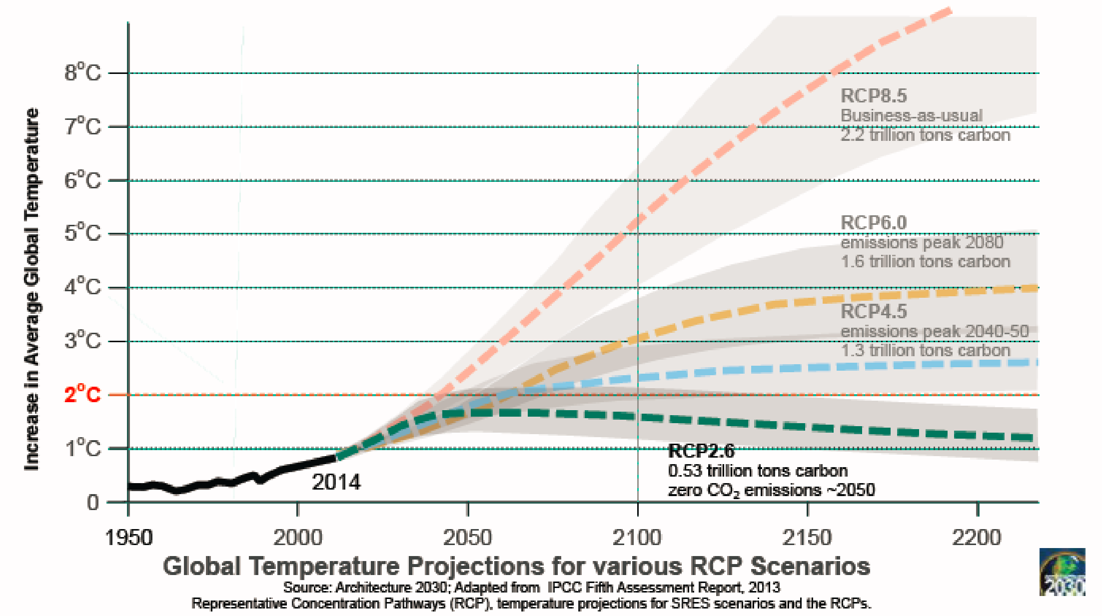
8-1 Getting to Zero

Edward Mazria, Professor, Architecture 2030. USA

- Pathways for Fossil Fuel Carbon Emissions to 2100.

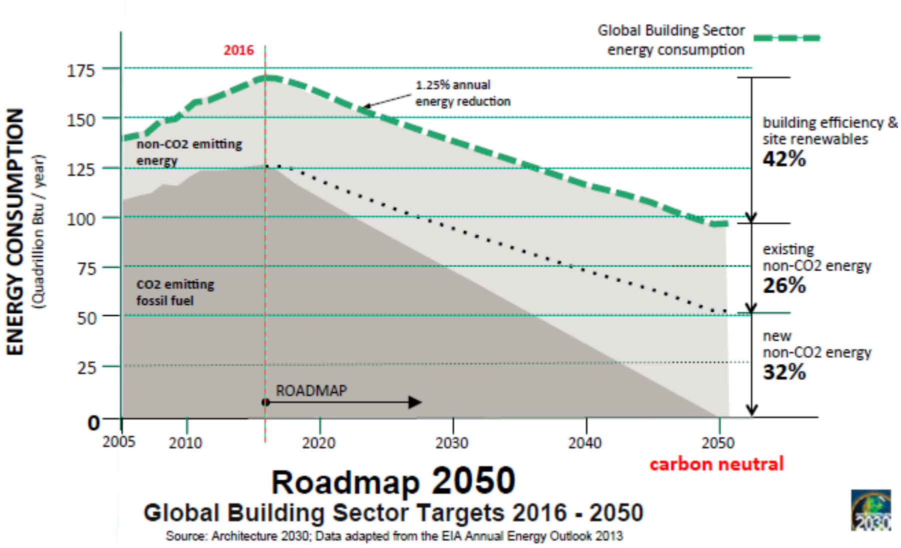


- Global Temperature Projections for various RCP Scenarios



- Emissions peak , eliminate CO_2 emissions by 2070 to have 66% chance of staying below 2ºC
- 533 cities worldwide are disclosing GHG emissions, that is a 70% increase since the Paris degree
- 7,477 cities with emissions reductions targets.
- A highly energy efficient building that produces on-site, and/or procures, enough carbon-free renewable energy to meet all building energy consumption annually.

  ZNC = Energy Efficiency + On-site/Off-site Renewable Energy
- Roadmap 2050



8-2 From Thousands to billions Coordinated Action towards 100% Net Zero Carbon Buildings By 2050

Victoria Burrows, Project Leader, World Green Building Council

- The World Green Building Council is composed of 5 Regional Networks to facilitate sharing of knowledge and resources. 32,000 member companies (members of the audience may be affiliated with!) Through our work, millions of lives impacted.
- The World Green Building Council is a member organisation with 76 member GBCs across the world.

- World leaders agreed to implement carbon reduction measures to ensure global temperature rises remain within 2 degrees, and ideally 1.5 degrees. Sectors will develop their own roadmaps, however the buildings sector is responsible for 30% of global carbon emissions and can play its part by going further than other industries.

- The group agreed on the following key principles:

  1) Carbon must be measured, in operation performance

  2) Decarbonisation will happen faster if we reduce energy demand

  3) Follow hierarchy, and district systems where appropriate

  4) Transparency in continuous improvement – for example expanding scope to embodied carbon

- The Theory Of Change that will move the market from the current less than 1% net zero buildings (shown bottom right of the screen) is shown here.

- Market Leadership Examples.

  Energiesprong (Netherlands)

  JPMorgan Chase & Co.

8-3 Green Financing and insurance in urbanization

Kevin Mo, Director, Paulson Institute

- Urbanization drives up the number and size of Chinese cities, and building energy use.

- Building is taking larger share of carbon budget, carbon emission profiles of central districts in some Chinese cities are already close to that of New York City.

- Financing Demand for low carbon cities---RMB 1.65 trillion (USD 250 billion) during 2016-2020, among which government Funds: <10%

- Green finance guidance to mortgage underwriting

8-4 Green Financing in building

Yao Yuan, Director, Greenliving Fund

- Ministry of Finance published “Temporary Management Provisions for Global Environmental Fund Projects” in 1997 to support international conventions that Chinese government agreed on and implement the sustainable development.
- SEPA and CIRC jointly announced “Guidance for Liability Insurances Regarding Environment Pollution” in 2007, the launch of Green insurance
- CSRC published “ The Announcement for IPO Application Procedures Regarding Heavy Polluting Companies” in 2008, indicating thermal-powered, steel, cement and electrolytic aluminum industries must obtain permission and inspection from SEPA before IPO application
- Excessive reliance on non-renewable energies, especially coal, is causing series of pollution problems in China. Heavy polluted industries require more specific regulations and industrial upgrade, in which green finance can play a very significant role
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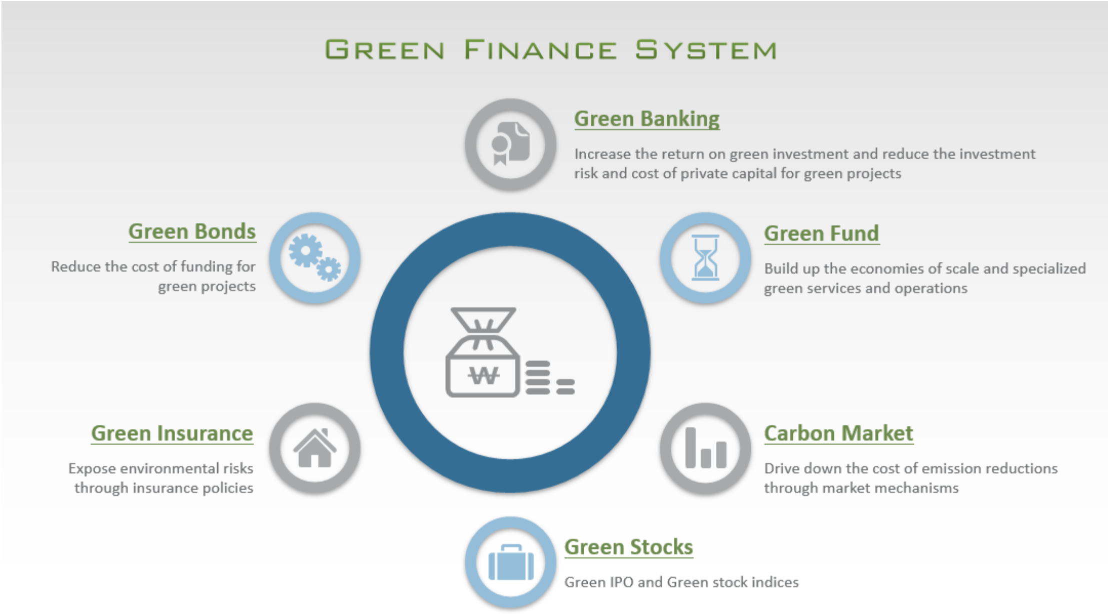
GREEN FINANCE SYSTEM
Green Banking
Increase the return on green investment and reduce the investment risk and cost of private capital for green projects
Green Bonds
Reduce the cost of funding for green projects
Green Fund
Build up the economies of scale and specialized green services and operations
Green Insurance
Expose environmental risks through insurance policies
Carbon Market
Drive down the cost of emission reductions through market mechanisms
Green Stocks
Green IPO and Green stock indices

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Conclusion

After the 3-days Symposium, experts and related stakeholders from APEC member economies were invited to discuss the challenges and obstacles during NZEB roadmap development under these factors and developing a solutions based approach for critical scenarios. The plenary speakers and their topic areas tied all of the research together that was presented in the panels.

The highlight conclusions can be summarized as followed:

1. Decreasing carbon emission in building area is the world-wide trend in the future

2. NZEB and Low Energy building pilot demonstrations are covering all kinds of building types and more climate zones

3. Many economies have setting long-term goals and specific policies on NZEB development, together with various financing incentive measures.

4. Latest progress on passive and active approaches have showed great achievements, like ground source heat pump system integration, and newly advanced material.

5. ZEB Certification is critical in further development