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Economic Cooperation

APEC 100 Best Practice Analysis of Nearly/Net Zero Energy Building

Energy Working Group

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Content

PREFACE

Energy use in buildings worldwide accounts for over 40% of primary energy use and 24% of greenhouse gas emissions. Simply increasing energy supply will not solve the current energy supply and security situation and associated environmental problems. Given the challenges related to climate change and resource shortages, making residential and non-residential buildings more energy and resource-efficient while maintaining thermal comfort and cost-effectiveness represents and enormous opportunity to save money and reduce pollution.

Accounting for around 60 percent of world energy demand, the APEC region is a net energy importer and its demand for energy is on the rise. Recently, some APEC developed economies set the goal to achieve Nearly /Net Zero Energy Building (NZEB) and already launched some research programs and accomplished successful demonstration projects. How to share the existing experiences and best practices of NZEB to promote this idea among APEC region is the main focus of this project which will benefit both the new building construct work and existing building retrofit work in both developed and developing economies.

This project was funded by the APEC-Energy Working Group: EWG 02 2015 - APEC Nearly /Net Zero Energy Building Best Practices and Energy Reduction Results Comparative Study, the APEC Expert Group on Energy Efficiency & Conservation managed the implementation of the project. The goal of this project is to carry out professional in depth comparative research with the detail information collected of best practice NZEB pilot buildings, to showcase how tremendous energy reduction could be achieved by integration design, advanced technology utilization and NZE oriented management & commissioning in buildings. The outcome of this project could be as a strong support for the APEC economies to promote NZEB in the future and also work as an important pillar for the existing APEC programs, which including APEC Energy Smart Communities Initiative (ESCI), APEC Smart Grids Initiative (ASGI) and APEC Low Carbon Model Town project (LCMT).

The project had accomplished:

（1）A comprehensive and systematic information collecting template that could cover necessary information of the NZEB best practice. The reference sources of the template includes IEA Joint SHC Task 40 program database, Nagoya City University, the Chinese MoHURD passive ultra-low energy consumption demonstrations investigation template, United States DOE NREL building database, ENOB energy-optimized construction database and the Construction 21 building database.

（2）Two successful workshops. Two NZEB pilot projects workshops were prepared in 2015 and 2016, 43 speakers and 165 participants attended the workshops. The summary of discussion on main challenges, threaten and risks during the design, construction and operation of Nearly/Net Zero Energy commercial building and residential building, experiences and suggestions of how to deal with those problems were shared.

（3）An extensive investigation and comparative study of different NZEB best practices which includes commercial building and residential building in all climate regions among APEC economies were carried out and 100 NZEB best practices from 8 economies (Australia; Canada; People's Republic of China; Hong Kong, China; Japan; Republic of Korea; Chinese Taipei and United States) were collected.

（4）The growth trend of NZEB in APEC member economies was analyzed, the various indoor temperature and relative humidity settings show a great different comfort requirement among each economies. The passive strategy, active approaches and renewable energy system were studied. The increment cost of different type of NZEB projects and the corresponding incremental allocations were analyzed.

We believe that the successful NZEB projects will be a powerful way to promote NZEB in building sector in APEC area. This report will show APEC economies what is the technology roadmap of different type of building in various climate zones across the APEC region. Meanwhile, this report will also strongly support the Energy Working Group Strategic Pan 2014-2018: Promote Energy Efficiency and Sustainable Communities, APEC Member Economies are more reliant on sustainable energy sources and energy efficient technologies and practices that reduce their overall energy consumption. Advancing the application of demonstrated energy efficiency practices and technologies contribute to international efforts to reduce the adverse impacts of energy production and consumption, and improve the analytical, technical, operational and policy capacity for energy efficiency and conservation within APEC Member Economies.

ACKNOWLEDGEMENT

The final report could not have been accomplished without the contributions of all experts who attended and shared their valuable experiences in two workshops of the project, collected information of best practice during their busy daily work. The APEC-EGEEC economy delegates and nominated delegates in APEC economies participated the two workshops and shared their ideas during the Q&A session and the discussion session. NSERC Smart Net-zero Energy Buildings Strategic Research Network of Canada and Industrial Technology Research Institute of Chinese Taipei gave us strong support for hosting the 2 workshops in Montreal and Taichung. We would like to thank you all.

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CHAPTER 1 General Information

Asia-Pacific Economic Cooperation (APEC) is the largest regional international organization and is also the vital platform for APEC region's international energy cooperation.

1.1 The APEC energy intensity goal

The APEC Energy Intensity Goal aims to reduce energy intensity for APEC as a whole by 45% over the period 2005 to 2035, but does not set out any economy-specific targets. It is a follow-on to the Sydney Declaration (2007), which aimed to reduce energy intensity by ‘25% from 2005 levels by 2030’.

In 2012, the St. Petersburg Declaration introduced an enhanced ‘aspirational goal to reduce aggregate energy intensity of APEC economies by 45% from 2005 levels by 2035’ (APEC 2012).

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

1.2 APEC high-level urbanization

Urbanization is a necessary path toward modernization and how to make this path sustainable and environmental friendly has been now a worldwide issue. The Asia-Pacific region’s innovative development, economic transformation and upgrading, and recent economic growth resulted in a rapid increase in energy demand.

The APEC Economic Leaders endorsed the APEC Cooperation *Initiative for Jointly Establishing an Asia-Pacific Urbanization Partnership* in Beijing in November 2014, to deepen urbanization partnership through collective efforts and concrete actions. To encourage member economies to deepen the Asia-Pacific urbanization partnership and realize Asia-Pacific goal of common development, prosperity and progress, 9 proposals are put forward to realize Asia-Pacific goal of common development, prosperity and progress, we choose five of them to list below[1]:

- Promote inclusive and dynamic urban growth.
- Improve urban infrastructure.
- Build smart cities.
- Develop green cities.
- Boost APEC cooperation on sustainable urban development.

In order to achieve this goal, the APEC National Energy Administration (NEA) selects a series of projects on advanced urban development technologies, concept, mode and solutions. The Low-carbon Modern Town (LCMT) projects have received more attention and established a sound research, development and implementation conditions during which their share of building energy consumption is once again emphasized.

Building energy consumption takes 30% to 40% of total primary energy in APEC economies and has a fast increasing trend in developing economies due to the urbanization rate increase and living standard improvements. The wide range promotion of NZEB and mass energy saving consciousness is the critical point to make NZEB achieve its real impact - clean, sustainable, low carbon emission goals in the building sector.

Nearly (Net) Zero Energy Building (NZEB) has been proved to be the most effective measure of reducing energy consumption in the building sector, and also work as an important pillar of LCMT and ESCI[2].

1.3 APEC Nearly/Net Zero Energy Building

According to UNFCCC 2015, carbon emissions during building LCA account for 30% of global carbon emissions and this proportion will be up to 50% if the building energy consumption continues at current speed[3]. This also increases risks and vulnerability of countries, regions and local communities to climate change impact. Rapid urbanization, especially in emerging economies is only going to accelerate this impact.

Since it is still at a growing stage, there is no unified definition for net zero energy building. Each economy put forward the definition in a constantly updated way.

1.3.1 Policies and program

Since the energy consumption of building cause more and more attention, for now, NZEB is starting at a rapid developing stage.

1.3.1.1 Canada

Approximately one third of Canada’s greenhouse gas (GHG) emissions are attributed to building energy consumption. Buildings also account for about 53% of Canada’s electricity consumption [4].

Through Natural Resources Canada’s Office of Energy Research and Development (OERD), the Government of Canada provides funding for research, development and demonstration (RD&D) projects to support innovation in clean energy sector. The funding programs administrated by OERD include Clean Energy Fund (CEF) initiated in 2009, ecoENERGY Innovation Initiative in 2011, the Energy Innovation Program (EIP) in 2016, and Program of Energy Research and Development (PERD). These funding programs supported the development and deployment of clean energy systems and building technologies that suitable for net-zero energy buildings and communities such as biomass-based urban central heating demonstration project in Quebec, community-level solar energy project in BC, cold climate air-source heat pump, BIPV/T, integrated air to water heat pump system for domestic hot water and space heating, high efficiency energy recovery and intelligent ventilation system for NZEH, etc.

The national target for Canada's public facilities is to reduce greenhouse gas emissions by 17 percent from the 2005 levels by 2020. Among the proposals for the 2016-2019 cycle is a proposal for public facilities to reduce greenhouse gas emissions by 30 percent from 2005 levels by 2030. The Federal Buildings Initiative (FBI) is a voluntary program that helps facilitate energy efficiency retrofit projects in buildings owned or managed by the Government of Canada. Developed and administered by Natural Resources Canada's Office of Energy Efficiency, it enables federal organizations to implement these projects through third-party energy performance contracts without necessarily using their own capital funds[1]. By this project, 15-20 percent of energy have been saved and this means a reduction of 235 kilotonnes of GHG emissions. Annual savings of $44 million have been reinvested into programs for Canadians while reducing the impact of government operations on the environment.

Other levels of government, institutions and private sector firms also draw on the FBI's experience for help in designing their own energy efficiency programs.

EQuilibrium™ is a national sustainable housing demonstration initiative, led by Canada Housing and Mortgage Corporation's (CMHC) that brings the private and public sectors together to develop homes, and eventually communities that are a model for sustainable living[5]. EQuilibrium™ homes are designed to address occupant health and comfort, energy efficiency and renewable energy production, resource conservation, reduced environmental impact and affordability. Fifteen projects were selected and eleven were built and monitored. The EQuilibrium™ housing initiative represents a vision for reducing the energy intensity and environmental impact of Canada's housing sector and supports the integration of renewable energy solutions with the design and construction of housing while helping Canada maintain a clean and healthy environment.

To increase the market adoption of net-zero energy homes (NZEH) by demonstrating the feasibility of net zero energy housing on a community scale in Canada, NRCan's Innovation and Energy Technology Sector led "Net-zero Energy Housing Community Demonstration Project" and $1.9 million from ecoENERGY Innovation Initiative fund was contributed to the project. Five homebuilders in four provinces built a total of 25 net zero energy and net zero energy ready homes. This project addresses the challenges in building NZEH performance levels specific to production housing and acts as a platform for the broader adoption of NZEH across Canada.

Canadian Home Builder Association (CHBA) founded the Net Zero Energy Housing Council (NZC) in 2014 to support CHBA members' voluntary adoption of Net Zero Energy Housing.

A pilot of the Net Zero Energy Labeling program developed by the CHBA was launched in 2015. The program provides the industry with a clearly defined yet rigorous 2-tiered (NZE and NZE Ready) technical stand that will distinguish and recognize builders and renovators and their NZE homes. To encourage high levels of industry adoption, the program is striving to keep the administrative process simplified. The CHBA Net Zero Home Labelling Program has been designed so that a home could still qualify for Net Zero Ready, R-2000, or ENERGY STAR ® if Net Zero isn't achievable. Net Zero Energy Ready Homes are up to 80% more energy efficient than homes built to code.

1.3.1.2 China

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.

Since 2006, The central government has issued a series of measures about BEE to respond to the challenge of rapid increasing building energy consumption owing to the increasing demand of more new buildings and household appliances, in the ‘‘Eleventh Five-Year Plan period’’.

The ***Passive Ultra-low Energy Green building Technical Guide*** was published by Ministry of Housing and Urban-Rural Development (MoHURD) in November, 2015 which was considered as China's first Ultra-low energy building technical guidance. Under the encouragement of MoHURD, a series of publicize, implement were conducted and in December, 2016, the first batch of Passive Ultra-low Energy building Certification were granted to 16 demonstrations, to announce the outstanding design, construction and operation. The fast development situation made Chinese government no choice but push great effort to improve building energy efficiency.

Besides central government, local government also adopted important fiscal incentive policies of building energy efficiency including: Special fund for energy efficiency of government office buildings and large-scale public buildings, Reward fund of energy efficiency retrofit for existing residential buildings in China's northern heating region, Special fund for demonstration of renewable energy application in building, Subsidy fund for building integrated photovoltaic (BIPV), Subsidy for city-level demonstration of renewable energy application, Financial subsidy for promotion of high efficiency lighting products.

1.3.1.3 Japan

In Japan, energy efficiency was connected strongly with energy security and cover a wide variety of industries. The Japanese government believes that energy efficiency policies for each sector should be complemented with policies to promote lifestyle changes and that the general awareness has to be increased.

(1) Energy Conservation Law

The Energy Conservation Law (ECL) was enforced in Japan in 1979 after the second oil crises and has subsequently been revised several times [6]. There are four major areas addressed by the ECL. Groups targeted in each area are:

- Housing and buildings: building owners/developers and managers
- Factories, etc: Managers of factories and workplaces
- Equipment and appliances: producers and importers of equipment and appliances
- Transportation: transport companies

(2) Action Plan and Roadmap of ZEH and ZEB

The program “Committee on Realization and Generalization of ZEB” was organized in 2009 in order to examine the roadmap to realization and generalization of Zero Energy Building (ZEB). By introducing energy saving measures for buildings, this committee proposed to realize ZEB as the standard for new buildings by 2030.

Ministry of Land, Infrastructure and Transport (MLIT), Ministry of Economy, Trade and Industry (METI) and Ministry of Economy (MOE) published the roadmap for ZEH and ZEB by 2030, eventually aim the realizing Life Cycle Carbon Minus (LCCM) building to reduce CO2 emissions throughout the housing lifecycle: construction, living, demolition, reuse and etc.

1.3.1.4 Korea

Among the various parts of energy consumption, according to *Energy Survey Report* (2011), Korea Energy Economics Institute, 21.2% of Korea primary energy was consumed by the building sector. According to Presidential Conference on Green Growth hold on November 5th, 2009, Korea tries to reduce 80% of cooling/heating energy in building sector by 2017.

Moreover, on July 17 2014, Ministry of Land, Infrastructure and Transport issued **The Activation Plan of ZEB Corresponding to Climate Change** on the 11th General Meeting of the Presidential Advisory Council on Science and Technology (PACST) which clearly analyzed the barriers and obstacles of ZEB promotion setting up the future roadmap step by step. The plan also showed the corresponding financial policy and subsidy for pilot projects, work distribution and calculation of the expected social, environment and economy effect.

1.3.1.5 United States

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

(1) For federal buildings.

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[7].

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) For Commercial and residential buildings.

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 [8]:

- 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.

1.3.2 Nearly/Net Zero Energy Building definition

From technical level, NZEB is a measure of a building’s energy performance, whereby it produces as much or more renewable energy as it uses over the course of a year in operation.

After years of development, NZEB has been the subject of research initiatives for institutions and scholars to pay attention to and there is still lack of a definition for NZEB which can reach worldwide consensus.

1.3.2.1 Canada

Canada lacks an official roadmap for the building sector addressed towards NZEB[11]. The term Net Zero Energy Housing (NZEH) rose out of the US Department of Energy’s Zero Energy Homes research initiative that started in 2000. In 2006, CMHC EQuilibrium™ Housing Pilot Demonstration Initiative describes a home that produces as much energy as it consumes annually. This is done through a variety of means, including [12]:

- Reducing energy loads through a climate-responsive, high-performance building envelope and use of energy efficient appliances and lights throughout the house
- Increased use of passive solar cooling and heating techniques
- High-efficiency mechanical systems that match the lower energy requirements of the home

- Space and water heating assisted by commercially available solar thermal systems and heat pumps
- Electrical use offset by grid-connected commercially available photovoltaic (PV) systems

The NSERC Smart Net-zero Energy Buildings Strategic Research Network (SNEBRN) mainly uses the following definition of a net zero energy building: a net-zero energy building is defined as one that, in an average year, produces as much energy (electrical plus thermal) from renewable energy sources as it consumes[13]. The production of energy from renewables on-site is the most difficult to achieve, but in sunny climatic conditions present in most of Canada, building-integrated solar systems make this possible, particularly for houses.

1.3.2.2 China

Since the1980s, energy-saving work in China has made remarkable achievements under the leadership of the ministry of housing and urban-rural development of the People’s Republic of China, especially in the aspects of reducing the energy consumption of public buildings and heating energy consumption of residential buildings in severe cold area and improving the proportion of renewable energy’s application [14,15]. At present, the 65% of energy efficiency standards are being executed[16,17], the building energy-saving work slowed down the Chinese building energy consumption continued rapid growth trend and improve occupants’ living environment.

The passive nearly-zero energy buildings in China is defined as " the buildings with the best envelope thermal insulation performance and air tightness, makes full use of natural ventilation, natural lighting, solar radiation and other technologies such as the passive method of getting energy from indoor non-heating source, minimizes the demands of heating and air conditioning and accomplishes the harmony and comfortable indoor environment. One of the key objectives of a passive nearly-zero energy buildings in China is to create a healthy and comfortable indoor environment. Meanwhile, the control performance criteria are very also vital to ensure the sound development of passive nearly-zero energy buildings.

The Ministry of Housing and Urban-Rural Development (MoHURD) published the “*Passive ultra-low energy consumption Green building technical guidance*” (Guidance for short) in November, 2015. The main performance criteria of Chinese passive nearly zero energy buildings are listed in Table 1-1[18].

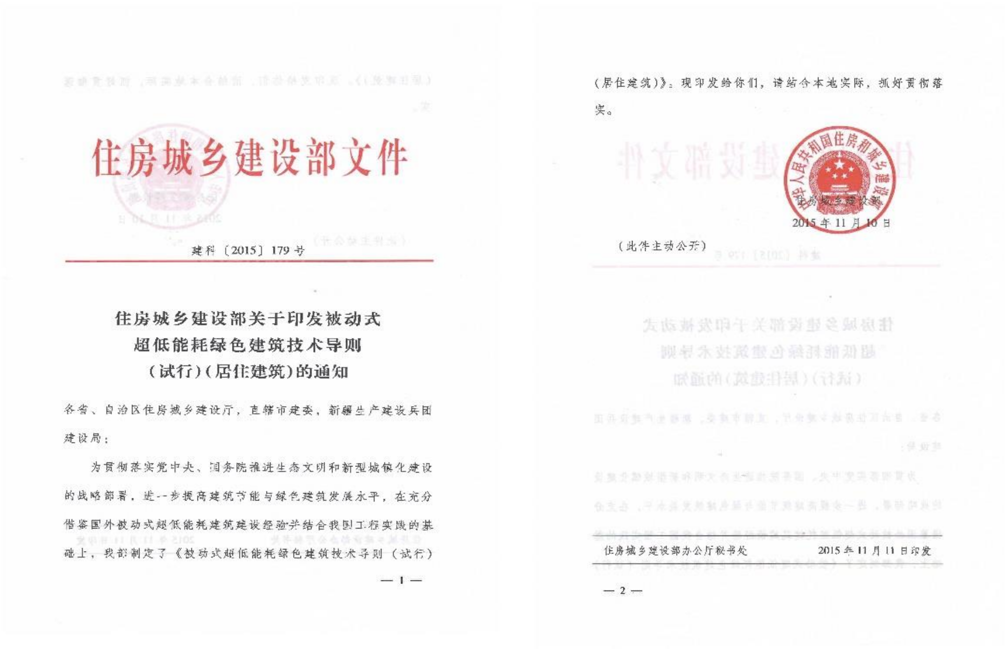
Table 1-1 Main performance criteria of Chinese passive nearly zero energy buildings

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

and lighting	
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.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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

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Figure 1-2 Passive ultra-low energy consumption Green building technical guidance

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.

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, an 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.

1.3.2.3 Japan

Japan has continued its efforts to promote buildings featuring and put up with a series of high performance building, such as "energy-efficiency building", "environmental-harmonious building", "green building", "low-carbon building" or "sustainable building". The economy launched an effort to promote net zero energy buildings using renewable energy technology in 2009.

According to the definition given by SHASE, NZEB is defined as:

"A building that consumes zero or nearly zero energy on an annual net basis by reducing primary energy consumption in the building as a result of enhanced energy efficiency performance of the building and facilities, neighboring buildings, on-site utilization of renewable facilities, networking of buildings, on-energy, and so on"

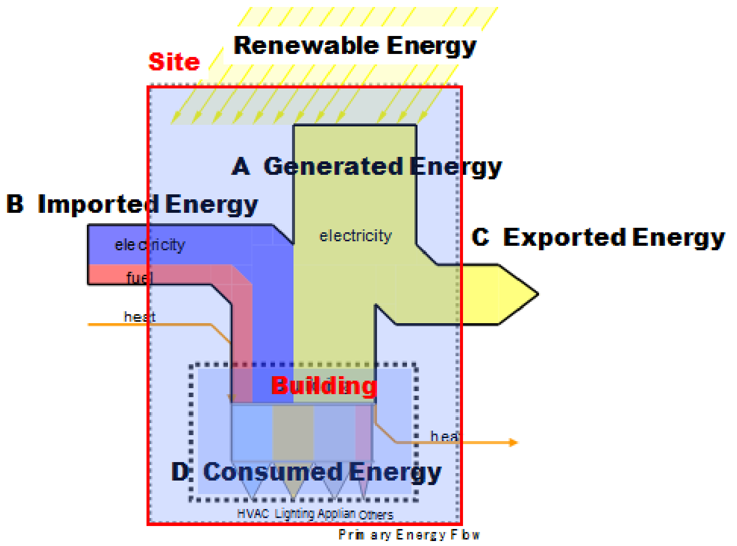


Figure 1-3 Primary Energy Flow of Net Zero Energy Building

Figure 1-3 explains the boundary of NZEB definition in Japan with on-site renewable sources. For a Net Zero Energy Building, the amount of generated energy should compensate or surplus the consumed energy in annual calculation. Renewable energy is on-site generation from on-site renewables, like solar, bioenergy, wind, etc.

From researching the definition of NZEB in Japan, a clear developing route can be concluded as: Low Energy Consumption Building--Sustainable Building-- Net Zero Energy Building--Zero Energy Building.

The Ministry of Economy, Trade and Industry (METI) has also created guidelines and standards for Net Zero Energy Building[19]:

ZEB and ZEH is a term to describe a building or house with zero net primary energy consumption annually, usually utilizing a combination of energy producing technologies including renewable energy and energy efficient facilities and systems.

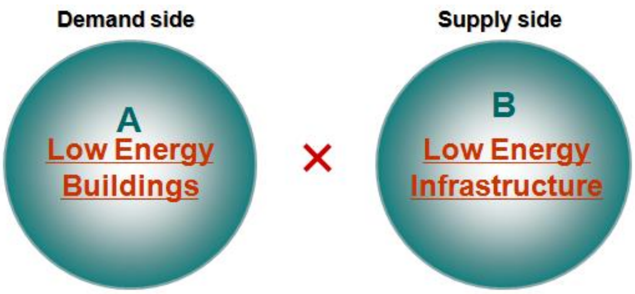


Figure 1-4 Energy Saving by the method of Demand and Supply Side

If: A*B=1.0*1.0=1.0 It is Reference Building

If: A*B=0.5*0.5=0.25 It is 75% Energy Saving Building

The goal is to achieve a net zero energy consumption by generating energy through photovoltaic power production while adopting "better insulation" and "higher equipment performance" set forth for ZEHs to achieve 20% energy savings. If energy savings of 75% of the net value is achieved, the Nearly ZEH status is granted. If energy savings of 100% or more is achieved, the ZEH status is granted.

1.3.2.4 Korea

In Korea, "Zero Energy Building" is defined as "A building that maximizes thermal insulation performance to minimize energy consumption, and uses renewable energies to provide energy self-sufficiently."

To accomplish zero energy buildings as soon as possible, Korea developed three kinds of zero energy buildings as follow:

Low-rise Zero Energy Building

A building that can provide energy required in cooling, heating, lighting and ventilation self-sufficiently within the corresponding site.

High-rise Zero Energy Building

A building that can provide energy required in cooling and heating within the corresponding site. It need to maximize the renewable energy system installations to provide the energy required in cooling and heating self-sufficiently, and the shortages can be covered by other renewable energy installations from nearby schools, parks, etc.

Zero Energy Building Town

It is to expand the range of zero energy from individual buildings to district units, and enforce the development targeting new towns and municipalities.

It is to utilize the use of recent technologies, such as Information & Communication Technologies, and linked with governmental R&D to aim for actualization of the avant-garde smart zero energy city.

1.3.2.5 United States

DOE and National Renewable Energy Laboratory (NREL) published "A Common Definition for Zero Energy Buildings" in 2015[9] which described the NZEB definition in four categories according to where renewable energy resources were shared.

- Zero Energy Building (ZEB)

An energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.

- Zero Energy Campus

An energy-efficient campus where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.

- Zero Energy Portfolio

An energy-efficient portfolio where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.

- Zero Energy Community

An energy-efficient community where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.

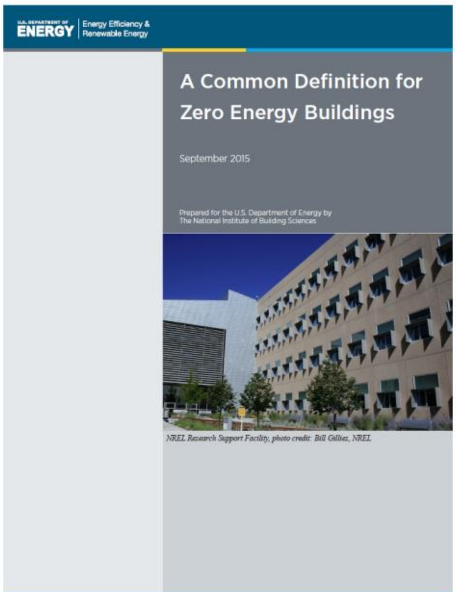


Figure 1-5 A Common Definition for Zero Energy Building

This definition makes clear of the energy calculation boundary—building, campus, portfolio, and community. Besides the definitions that proposed in the governments' policies and national program reports, many other institutes also present definitions according to their research work. New Buildings Institute (NBI) is leading in NZEB research and dissemination, its Zero Net Energy (ZNE) definition is one that has been widely used [10]:

The amount of energy provided by on-site renewable energy sources is equal to the amount of energy used by the building.

More recently, in 2016 Architecture 2030, New Buildings Institute, and Rocky Mountain Institute issued a definition for Zero Net Carbon (ZNC) buildings to accommodate all building types – new and existing residential, commercial, institutional, and industrial buildings – in various settings, including those located in dense urban environments where on-site renewable energy production may be limited. A ZNC building is defined as:

> *A highly energy efficient building that produces on-site, or procures, enough carbon-free renewable energy to meet building operations energy consumption annually.*

Current definitions of NZEB, ZEB, and ZNE are compatible with the ZNC definition because they all accommodate offsets for carbon-based energy consumption from energy efficiency and new renewable energy capacity. These definitions represent a narrower path for achieving ZNC and are specifically applicable to locations that have enough on-site renewable energy production capacity to meet annual energy demands. However, these definitions are limited in application to mostly low-density, low-rise, suburban, or rural building applications. The ZNC definition is intended to be more applicable to the growing dense urban developments in the APEC region.

The ZNC definition is closely aligned to the European definition of a Nearly-Zero Energy Building (NZEB) as it also allows for accessing nearby off-site generated renewable energy. While all energy and greenhouse gas emissions reduction targets are important, with the move to a carbon emissions-free built environment by 2050, all strategies will converge to meet the ZNC definition.

1.3.3 APEC Nearly/Net Zero Energy Building program

(1) EWG 03 2013A -Nearly (Net) Zero Energy Building Program

The APEC Nearly/Net Zero Energy Building Program first began in 2013, EWG 03 2013A - Nearly (Net) Zero Energy Building which responds to the declaration at the 9th APEC Energy Ministers Meeting, held in Fukui, Japan on 19 June 2010, they noted that the introduction of low-carbon technologies in city planning to boost energy efficiency and reduce fossil energy use is vital to manage rapidly growing energy consumption in urban areas of APEC. The goal of Project EWG 03 2013A is to enhance mutual understanding of economy’s building energy saving code--the policy, definition, R&D programs, related associations of NZEB among APEC economies were studied and experiences were shared. Two workshops were held during the project:

- The *APEC workshop on Nearly/Net Zero Energy Building* was held in Beijing, China on 30-31 October 2013 with 35 speakers and 70 participants from 11 economies attended the workshop.
- The *APEC workshop on Nearly/Net zero energy building & Community* workshop was held in Beijing, China on 22-23 October 2014 with 21 speakers and 80 participants that from 20 economies attended the workshop.

1st APEC workshop on Nearly/Net Zero Energy Building

2nd APEC workshop on Nearly/Net zero energy building & Community

Figure 1-6 Two workshops of project EWG 03 2013A

(2) EWG 02 2015A - APEC Nearly (Net) Zero Energy Building Best Practices and Energy Reduction Results Comparative Study

This project EWG 02 2015A - APEC Nearly (Net) Zero Energy Building Best Practices and Energy Reduction Results Comparative Study is a continuation of Project EWG 03 2013A. The distinction from the previous project is this project will carry out professional in depth comparative research with the detail information collected of best practice NZEB pilot buildings, which was didn't covered in the previous project, to showcase how tremendous energy reduction could be achieved by integration design, advanced technology utilization and NZE oriented management & commissioning in buildings. Two NZEB pilot projects workshops were prepared in 2015 and 2016:

- The *APEC-CZEBS iiSBE Smart Net Zero Resilient Buildings and Communities Net Zero Built Environment Symposium* was held in Montreal, Canada on 20-21 August 2015 focusing on sharing the information of existing commercial pilot projects. 35 speakers and 130 participants attended the workshop (See Appendix IV for the meeting notes);
- The *APEC workshop on Nearly/net zero energy building– From best practices to mass market* was held in Taichung, Chinese Taipei on 11 April 2016. 8 speakers and 35 participants from 11economies got together to discuss the different technology roadmaps of low-rise and high-rise residential buildings in various climate regions (See Appendix V for the meeting notes).

3rd APEC-CZEBS iiSBE Smart Net Zero Resilient Buildings and Communities Net Zero Built Environment Symposium

4th APEC workshop on Nearly/net zero energy building– From best practices to mass market

Figure 1-7 Two workshops of project EWG 02 2015

(3) EWG 15 2016A APEC Nearly (Net) Zero Energy Building Roadmap Study responding to COP21

As the continuation of project EWG 02 2015, the project EWG 15 16A have been approved by APEC secretariat in October, 2016. The objective of this program is 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.

The project EWG 15 2016A started on November, 2016 and will be completed in December, 2017. As an important supplement to trading regimes, this project will contribute to enhanced economic cooperation on building materials and building energy systems, equipment and appliances, thus promoting regional economic integration, leading to the fourth statement on Peru’s Priorities.

CHAPTER 2 NZEB Best Practices Template Design

On the basis of previous study, an in depth comparative research to the latest NZEB best practices is take with the questions:

(1) How many demonstration building are already built and under built with the objective to achieve NZE in APEC regions. What is the distribution in building type and climate zone?

(2) What technologies are used in the demonstration building and what is the real energy reduction result of different technologies compared with the regular building energy system?

(3) How to further promote NZEB in APEC region according to the best practices that had already existed.

This APEC NZEB best practices information collection template is at the request of APEC project EWG 02 2015A: APEC Nearly (Net) Zero Energy Building Best Practices and Energy Reduction Results Comparative Study, which aims at helping collecting information existing NZEB demonstration projects that could cover complete and necessary information of the target project, thus to take a comparative study of various best practices.

2.1 Key information analysis for NZEB best practice

The Nearly/Net Zero Energy Building sector, including the residential and services sub-sectors, uses a wide array of technologies. They are used in the building envelope and its insulation, in space heating and cooling systems, in water heating, in lighting, in appliances and consumer products, and in business equipment. The long lifetime of buildings and related equipment are both important influencing factors for building energy consumption, especially for NZEBs.

Some of the technologies needed to transform the buildings are already commercially available and cost effective, with an economic payback periods.

2.2 Support materials for NZEB best practices template design

(1) IEA Joint SHC Task 40 Building information template

During the program, the team of SHC Task 40 Task C developed the building factsheet and investigate for 30 Net ZEBs case studies, the website of the report *Solution Sets and Net Zero Energy Buildings ---A review of 30 Net ZEBs case studies worldwide* can be found at: http://task40.iea-shc.org/data/sites/1/publications/T40A52-DC-TR1-30-Net-ZEBs.pdf

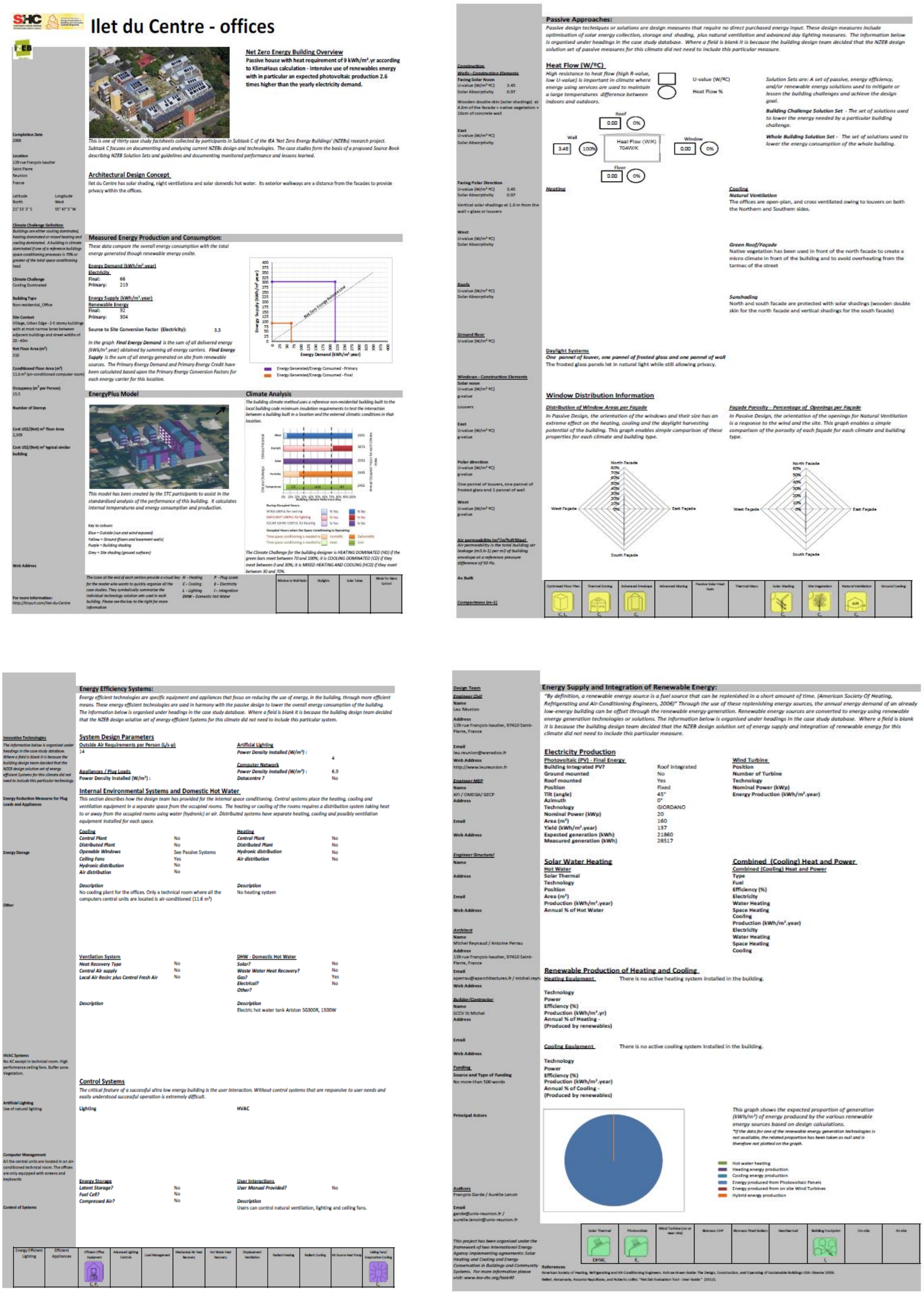


Figure 2-1 IEA Joint SHC Task 40 Building information template

(2) Japan NZEB template

The template model provided by Prof Gyuyoung, and Dr Niwa which was proposed to present energy balance for providing and demanding energy amount. Based on this template, 13 cases were investigated and studied. The template is short but can clearly show the composing of system outline, used energy conversion factor, demanding and supplying energy flow.

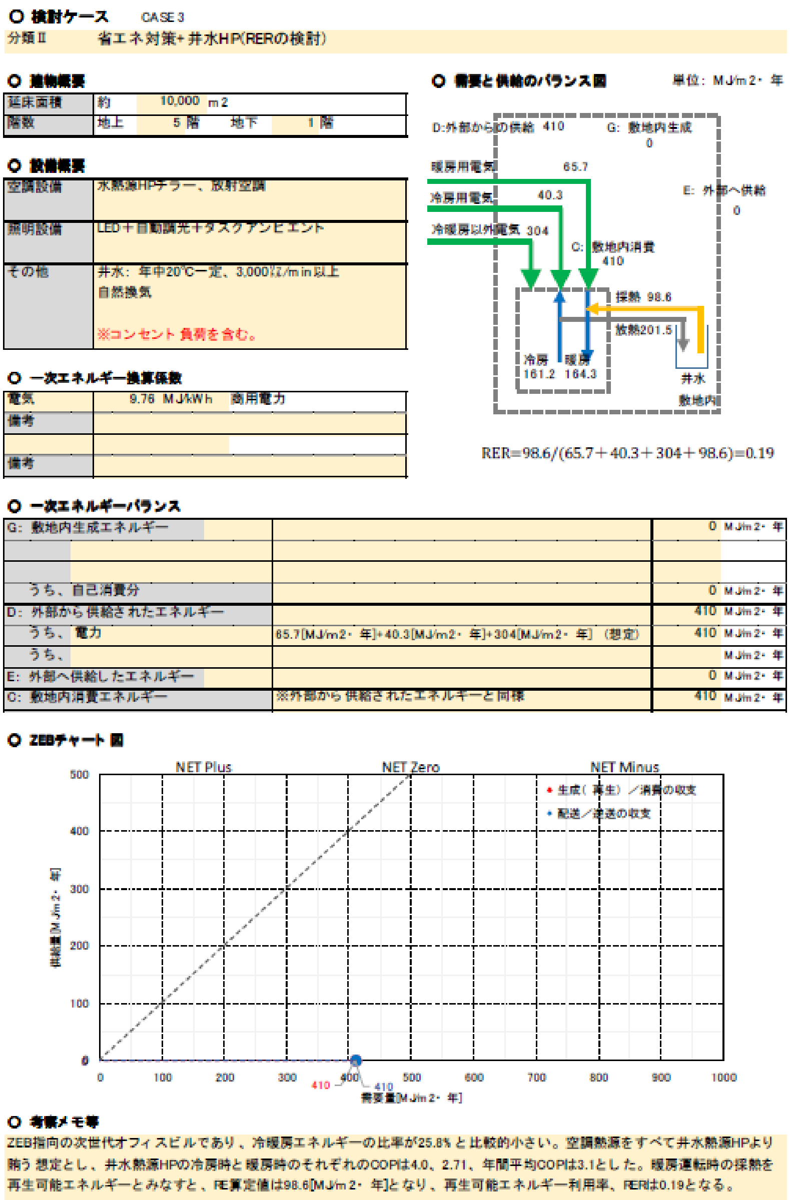


Figure 2-2 Japan NZEB investigation template (SHASE)

(3) China Passive ultra-low energy consumption of green building projects investigation

The MoHURD conducted an investigation in 2014 to the existing passive ultra-low energy consumption demonstrations nationwide. 35 pilot demonstration accepted the investigation. The template was developed by China Academy of Building Research (CABR) and China Passive Building Alliance (CPBA), as shown below.

Passive Ultra-low Energy Building Project Investigation				
Basic Information				
Building Name		Location	Province City District	
Floor Area (m^2)		Building Type	□Residential □Public □Both	
Starting Date		Completion Date		
Project Unit		Construction Unit		
Design Unit		Simulation Software		
Certification	(National Level, Provincial, city level demonstration/ Sci-Tech Support Plan; Other green building certifications)			
Contact Person	Name		E-mail	
	Institute/Company		Telephone	
Key Technical Indexes				
Energy consumption Target	Energy Consumption Targets	Design Value	Testing Value	
	Heating load (W/m^2)			
	Cooling load (W/m^2)			
	Primary Energy Consumption kWh/(m^2)			
	Air tightness (m^3/m^2 h@50Pa)			
Construction Elements (Building Envelope)	Roof U-value (W/m^{2}K)			
	Wall U-value (W/m^{2}K)			
	Impracticable Floor U-Value (W/m^{2}K)			
	Basement Roof U-Value (W/m^{2}K)			
	Window U-value (W/m^{2}K)			
	Solar heat gain coefficient (SHGC)			
	Surrounding ground U-value (W/m^{2}K)			
	Basement external Wall U-value (W/m^{2}K)			
	Other Index			

Passive Ultra-low Energy Building Project Investigation				
Indoor environment	Indoor Temperature (℃)			
	Indoor Relative Humidity (%)			
	Indoor Air Quality (CO_2 ppm)			
	Other indoor requirement			
Energy saving approaches				
External Wall	Thermal Insulation Type			
	Material Category:		Material thickness	
Window	Numbers of glass layers		Fill content	
	Coating material		Window frame structure	
Sun shading	Shading type			
	Sun shading devices		Movable or not	
Key principal for heat bridge				
Energy system	Heating system energy sources		Cooling system energy sources	
	Domestic hot water energy sources		Others	
Heat recovery	System patterns		Heat recovery efficiency	
Other solutions				
Other Technical Documents				
1. Feasibility Study Report 2. Energy Saving Calculation Report 3. Detail drawings for Key Heat Bridge 4. Construction Design Description 5. Test Report of Indoor Environment and Energy Consumption				

Figure 2-3 China Passive Ultra-low Energy building investigation template

(4) United States DOE NREL building database

The U.S. Department of Energy and the National Renewable Energy Laboratory (NREL) developed the high performance building database providing a unique central repository of in-depth information and data on high-performance, green building projects across United States and abroad. This collaboration increases the reach of the information and saves building designers and owners from having to provide the same information to multiple sources.

The Database includes information on the energy use, environmental performance, design process, finances, and other aspects of each project. Members of the design and construction teams are listed, the websites of the database can be found at: https://buildingdata.energy.gov/

The high performance building database provided a good example for building information collection, from general information, energy consumption, indoor environment, design process, financial and other information that can collected from projects.

Figure 2-4 United States DOE NREL building database

(5) ENOB energy-optimized construction database

"Buildings of the future" is the guiding concept behind EnOB – research for energy-optimized building. The research projects sponsored by the German Federal Ministry of Economics and Technology involve buildings that have minimal primary energy requirements and high occupant comfort, with moderate investment costs and significantly reduced operating costs.

The buildings in the energy-optimized construction database are divided as new buildings and refurbishment buildings, together with other new technologies, software, and analysis. The key parameters of each project are recorded in fixed template, as is shown in Figure 2-5 which covers the basic information, description, research focus and energy consumption level.

The database is under continuously updating and have covered probably 40 new buildings and 30 refurbishment buildings. The websites of the database can be found at: http://www.enob.info/en/

Single-family homes with renewable electricity and heat provision

EnBau

Climate-neutral building concepts are more in demand than ever before as a result of the latest energy policy requirements of the EU and the German federal government. In Freiberg, the performance of two single-family homes conceived as energy self-sufficient buildings was scientifically investigated for two years. For two different utilisation profiles, it can be shown that high solar coverage levels are possible, particularly for the power and heat provision. The buildings have a very low heating requirement, which is largely covered by generously dimensioned solar collectors and heat storage units. There is also a wood-fired, water-cooled stove. A photovoltaic system in combination with a battery storage unit ensures almost 100 per cent solar power provision. The building concept is now being marketed by a construction company.

The two identical single-family homes in Freiberg rely on completely renewable electricity and heating supplies. Photo from summer 2014.
© Timo Leukefeld

Building summary

Project status	Evaluated
Location	Franz-Mehring-Platz 10d, 09599 Freiberg, Sachsen
Completion	10/2013
Inauguration	11/2013
Building owner	Timo Leukefeld, Stephan Riedel
Operator	Timo Leukefeld, zugleich Nutzer
Gross floor area	279 m^2
Heated living area	206 m^2
Usable floor area (according to EnEV)	206 m^2
Measured energy characteristic values (in kWh/m2p.a.)	466 m^2
A/V ratio	0.72 m^2/m^3
Key aspects	Heat insulation, Glazing + windows, Optimised lighting, Ventilation + heat recovery, Regenerative + passive cooling, Thermo-active building element systems, Heat / cold storage, Control technology, operational management, building automation, Solar thermal energy, Photovoltaics, Biomass utilisation, Ecology of building materials

Figure 2-5 ENOB energy-optimized construction database

(6) Construction 21 building database

Construction21 is a collaborative platform dedicated to building professionals, to help them discover and develop new ways of sustainable building. Initially developed with the support of European Union (IEE project), Construction 21 platforms are managed by non-profit and academic organizations closely linked to building sector in each country.

Each of the project that collected in the database was acquired to fill in an information template, which can cover detailed project information (as is shown in Figure 2-6). The website of the database is: http://www.construction21.org/case-studies/

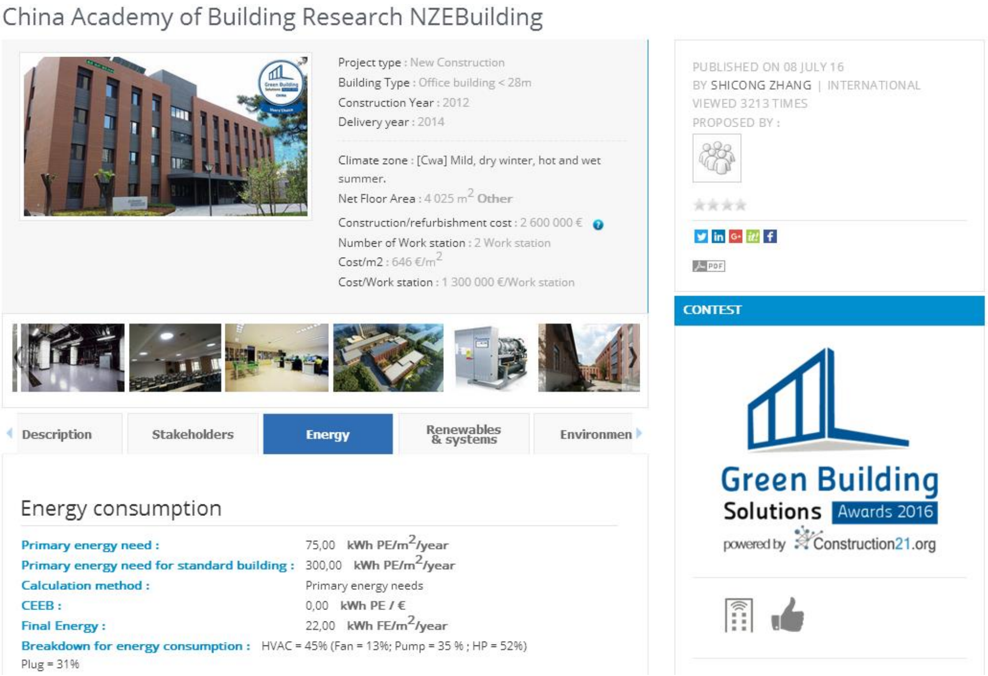


Figure 2-6 Construction 21 building database

2.3 The APEC NZEB Best Practices Information Collection Template

From the support materials above, we summarized the basic and necessary information that NZEB demonstrations should provide and developed the APEC Nearly/Net Zero Energy Building Best Practices Information Collection Template which is shown as below.

APEC Nearly (Net) Zero Energy Building

Best Practices Information Collection Template

Basic Information					
Building Name		Location (City)			
Building Type	□Residential □Office □School □Others (Please Specify)________				
Heating Degree Day		Cooling Degree Day			
Net Floor Area (m^2)		Treated floor area (m^2)			
Number of storeys	F/ BF	Completion Date			
Cost USD /m^2 (Net Floor area)		Cost USD/m^2 (of typical similar building)			
Incremental Cost Allocation (%)	□Passive approaches (%) □Active approaches (%) □Renewable energy system (%) □Control system (%)				
Source of Incremental Cost	□Government Subsidy (%) □Project Incentive (%) □Self-fund (%) □Donation/Industry in-kind support (%)				
Contact Person	Name		E-mail		
	Institute/Company				
Key Technical Indexes					
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical similar building**		
	Heating load (W/m^2)				
	Cooling load (W/m^2)				
	Annual Heating Demand (kWh/m^2a)				
	Annual Cooling Demand (kWh/m^2a)				
	Primary Energy Consumption kWh/(m^2)				
	Source to Site Conversion Factor (Electricity)				
	Primary Energy Consumption Including: □Heating/Cooling □Lighting □Plug				
Building energy codes or standards					
Construction Elements	**Technical Indicator**	**Design Value**	**Standard Value**		
	Roof U-value (W/m^2K)				
	Wall U-value (W/m^2K)				

1

(Building Envelope)	Window U-value（W/m²K）				
	Solar heat gain coefficient (SHGC)				
	Air tightness (m³/m² h@50Pa)				
Renewable Energy	Energy Category	Main Parameters			
	Solar Thermal				
	Photovoltaic				
	Biomass –fired Boiled				
	CHP				
	Wind Turbine				
	Air Source Heat Pump				
	Ground Source Heat Pump				
	Total Energy Supply kWh/m²				
Indoor environment	Indoor Temperature (℃)				
	Indoor Relative Humidity （%）				
	Indoor Air Quality（CO_2 ppm）				
Energy saving approaches（Yes for √）					
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain	
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading	
	Others (Please Specify)				
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	Other (Please Specify)				

2

Figure 2-7 APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template

2.4 The APEC NZEB best practices investigation and collection results

This APEC NZEB best practices information collection template is at the request of APEC project EWG 02 2015A:APEC Nearly (Net) Zero Energy Building Best Practices and Energy Reduction Results Comparative Study, which aims at helping collecting information of different NZEB pilot projects among APEC economies, thus to take a comparative study of various best practices .

The template was sent to 18 experts over 8 economies: Australia; Canada; People's Republic of China; Hong Kong, China; Japan; Republic of Korea; Singapore; Chinese Taipei and United States. By sorting and filtering the feedback results, 100 best practices were selected and analysed, the results was shown in this report.

Since the information and data of some projects are commercially sensitive, we only list projects which have been authorized to disclose the information. For the detail information, please see the attachment that listed below:

Appendix I The 100 NZEB Best Practices List

Appendix II Figures of 100 NZEB Best Practices

Appendix III Selected Best Practices Information Template

CHAPTER 3 General Information of NZEB Best Practices Investigation

Energy use in buildings worldwide accounts for over 40% of primary energy use and 24% of greenhouse gas emissions. Accounting for the energy demand, some APEC developed economies set goals to achieve NZEB and already launched some research programs and accomplished successful demonstration projects. To conduct a comprehensive analysis of NZEB development, including technical solutions, we conducted an investigation on existing NZEB pilot demonstrations.

3.1 The growth trend of NZEB in APEC regions

The major difference between NZEB and current buildings is the reductions in energy use and greenhouse gas (GHG) emissions and this difference requires a fully innovative and integrated technical design. The statistical results of the 100 investigated projects shows that a rapid growth trend occurred in 2012 with 15 projects completed, and the amount of large scale NZEB projects began to rise in 2013 with 5 projects more than 5,000 square meters.

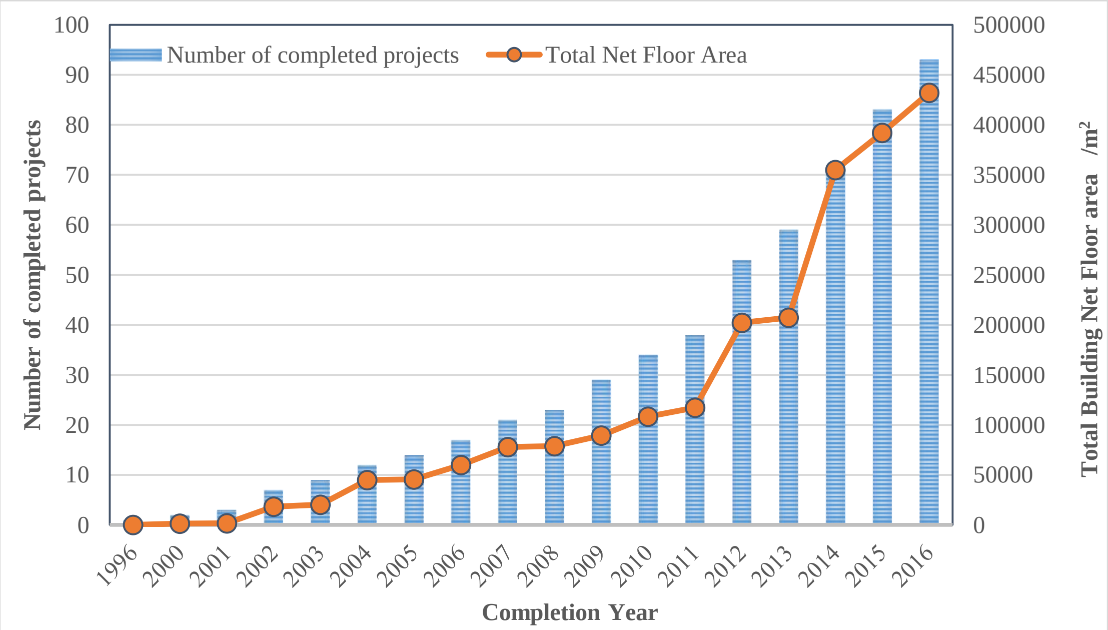


Figure 3-1 The Growth Trend of NZEB in APEC region

3.2 Building type and scale

The 100 best practices cover from residential to public and can be divided into 8 types in total--. Office, residential, multi-purpose, school, public service, museum & exhibition, library and others. Among the various types of building, office and school account for nearly half of the projects, offices account for 37% of the total and schools account for 12%. From the analysis of fund sources it is not hard to show that offices and schools can usually acquire more support from governments. Comparing with other building types, residential building including residential campus is easier to achieve zero energy and account for 17% of the total.

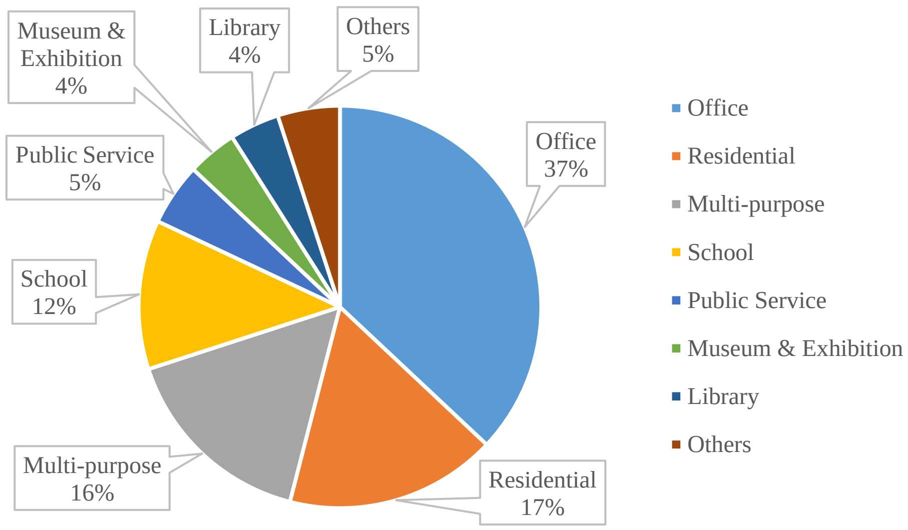


Figure 3-2 Building Type

The multi-purpose building are buildings with integrated functions, for example：

【Best Practice】Magnify Credit Union - South Lakeland

Magnify Credit Union - South Lakeland (Figure 3-3), an integration of office and retail store. Design of multi-purpose NZEB should consider the energy demand for each part and this may turn out to be a complementation balance if conducted with a good design.

Figure 3-3 Magnify Credit Union - South Lakeland, United States

【Best Practice】THE SMALLEST NZEB—NREL WIND SITE ENTRANCE BUILDING

Among the 100 NZEB practices, building scale various in a significance difference. The smallest NZEB practice is NREL Wind Site Entrance Building (SEB) which is a 15 m^2 building serves as a guard post at the entrance to the National Renewable Energy Laboratory's Wind Site Research Area. Although small, the building is representative of many guard facilities, remote restrooms, and outposts. The technologies used here could easily be scaled up to create single-story buildings for retail and office spaces, visitor centers, and contact stations. High value was placed on design simplicity to avoid complicated control schemes.

Figure 3-4 NREL Wind Site Entrance Building (SEB), United States

The largest NZEB project of the 100 investigations is an office building in Tokyo, Japan with 104,000 m^2 net floor area.

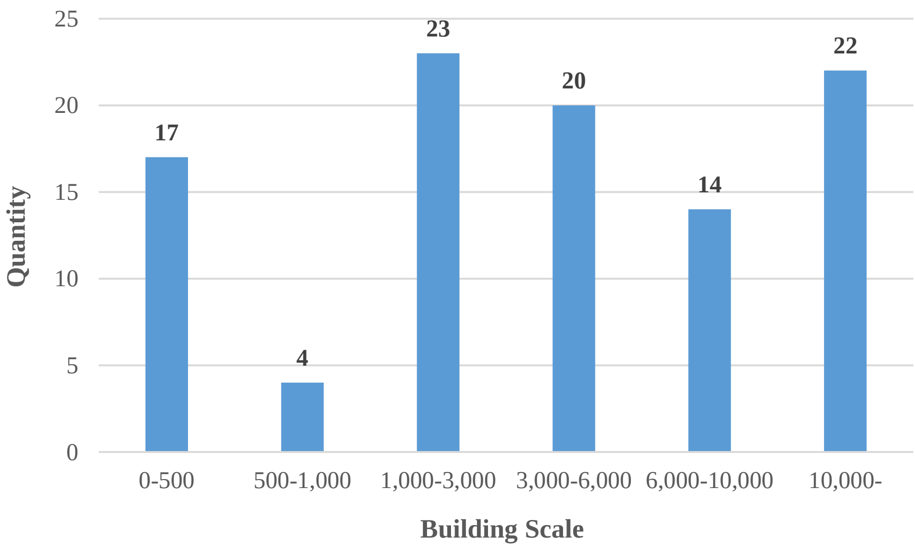


Figure 3-5 Building Scale

Figure 3-5 shows the statistical result of various building scale. It is surprised that there are 25 projects over 6,000 m^2 and 14 of them over 10,000 m^2. Among the large scale NZEB projects, the appearance of residential campus is a landmark progress for NZEB.

【Best Practice】Jinchun Zero-Energy Town

Jinchun Zero-Energy Town (Figure 3-6) is consisted of 100 detached houses and the renewable energy supply can cover all the energy demand. The project is under construction and will be accomplished in 2019.

Figure 3-6 Jinchun Zero-Energy Town House, Korea

3.3 Indoor environment quality (IEQ) in NZEB

Comfort was once considered something that occupants passively tolerate, more recent research has recognized that occupants adapt themselves and their environment in order to improve comfort. But for NZEB, comfort is critically assessed throughout the design and operation process. Here, indoor temperature, indoor relative humidity and indoor air quality are taken as the comfort index during the investigation.

3.3.1 Indoor temperature

Indoor environment of NZEB projects have great differences among various nations. Each NZEB demonstration design should follow local design specifications and standards. Commonly, most of the indoor design temperature is 25-26 ℃ in summer and 18-20 ℃ in winter.

Taking Energy Saving as the first priority, Japan has put great effort in cutting down building energy consumption. Some of the office indoor temperature are set to 28 ℃ to reduce cooling demand and use radiant cooling system as the comfort compensation.

For some region, dehumidification is a key influence factor that requires lower indoor temperature, like Hong Kong, China and Singapore, for example.

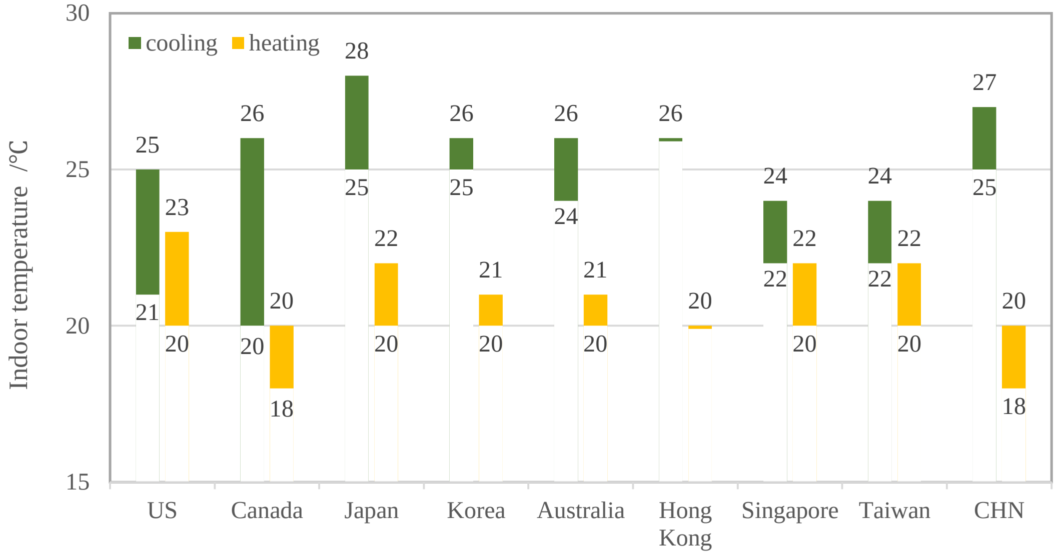


Figure 3-7 Indoor temperature setting

3.3.2 Indoor relative humidity

Compared to indoor temperature, the relative humidity of indoor air is also an important factor of body discomfort, especially for those hot and humid climate zones. For high temperature, humidity region, the more rigid humidity requirement, the lower temperature of the chilled water (for traditional HVAC system) and meanwhile, the higher cooling demand. The upper limit for China, Hong Kong, China, Singapore, and Chinese Taipei are set to 70% to reduce the cooling energy consumption.

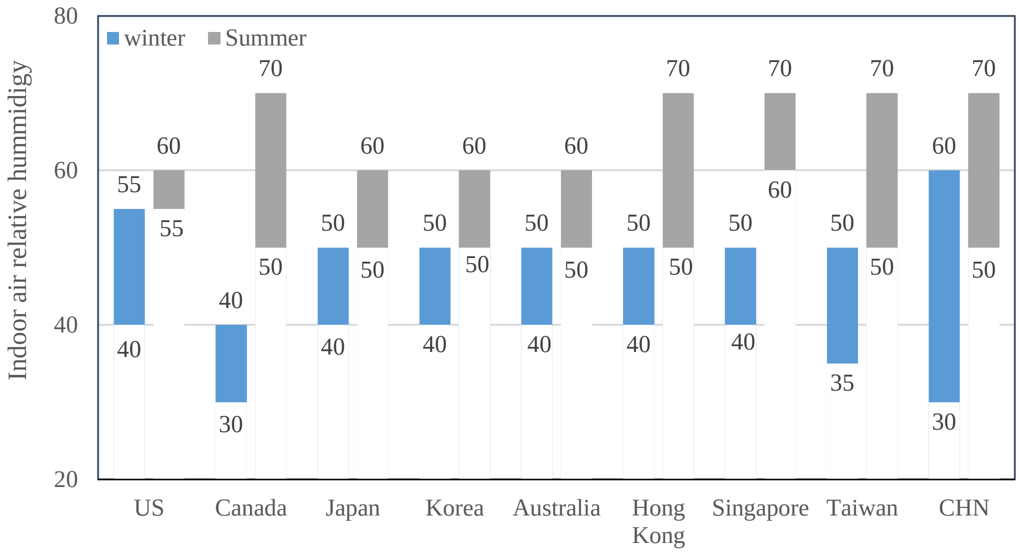


Figure 3-8 Indoor relative humidity

3.3.3 Indoor air quality

Indoor air quality is a measure of the healthiness and comfort of air in buildings. Modern buildings tend to have high concentrations of occupants and materials that can compromise healthy IAQ unless sufficient solutions are implemented. Contaminants in the air are normally categorized as gaseous, particulates, or microbial. In large scale public buildings, such as large-scale shopping centre and office block, the composition of contaminants is usually very complex. For residential buildings, a commonly used index is CO_2 concentration which is easy for detection and can be taken as the fresh air volume control index. For now, the worldwide recognized CO_2 concentration standard is not higher than 1000 ppm.

3.4 Climate assessment

Climate is a critical variable in the design of a NZEB project. It can not only influence the external thermal loads of a projects, but also decide the whole technological route. Heating Degree Days (HDD) and Heating Degree Days (CDD) calculation are the first step during the design process which are commonly used to estimate energy consumption in the thermal design of the building. However, the various base temperature that adopted during the HDD and CDD calculation show different HDD and CDD values. Table 3-1 shows the heating and air conditioning base temperature among the investigated economies.

Table 3-1 Base temperature of heating and cooling

Economy	Base temperature that adopted in HDD/CDD calculation	
	Temperature adopted in HDD / ℃	Temperature adopted in CDD / ℃
Australia	20	23
Canada	20	23
Hong Kong, China	18	23
Japan	18	26
Korea	20	23
People’s Republic of China	18	26
Chinese Taipei	18	23
United States	20	23

From the investigation it can be shown that the indoor temperature are designed at a different baseline and this made a wide difference on HDD and CDD values. For the winter indoor environment, Hong Kong,China, Japan, People’s Republic of China, and Chinese Taipei set the indoor temperature not lower than 18 ℃ but for Australia, Canada, Korea and United States, this baseline was set to 20 ℃. This means a higher comfort requirement and meanwhile, larger heating demand. As for the summer indoor environment, Japan and China’s indoor temperature was set 26 ℃, and the other investigated economies set the value as 23 ℃ or lower.

HDD and CDD values are usually taken as the reflection of local climate characters during building HVAC system design. However, different base temperature may lead to different HDD and CDD values. Higher HDD and lower CDD all means larger heating and cooling demand. Figure 3-2 shows HDD and CDD values of different locations. If calculated with unified base temperature, the HDD and CDD values will be higher than the current investigation results.

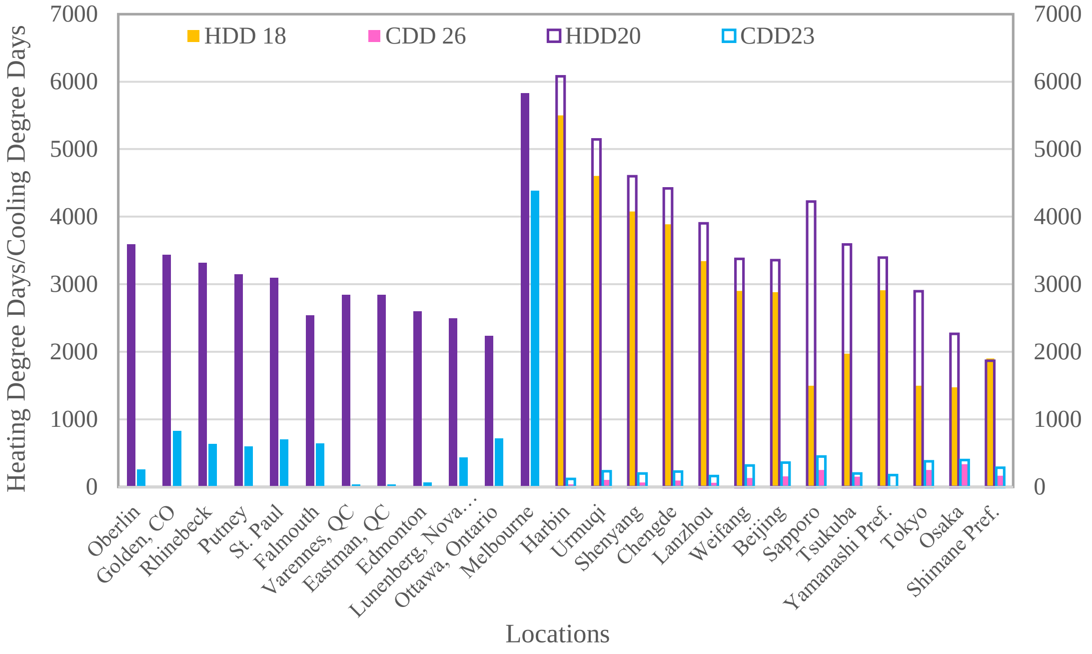


Figure 3-9 HDD and CDD of the projects locations

Actually, the gift of free energy is available in any climate, in different forms and quantities. The 100 best practices in this report nearly cover all the climate types

3.5 Building energy consumption

For Zero Energy Building (ZEB), it requires the building producing enough renewable energy that can totally cover the annual energy consumption requirement and thereby cutting down the non-renewable energy consumption. As for NZEB, the energy that consumed and generated are not fully equalled. Figure 3-10 shows the primary energy consumed and generated for each projects. Since some of the project don't have energy consumption monitoring data, Figure 3-10 contains 35 project energy consumption data.

During the energy consumption statistics, a key problem emerged that made the NZEB building consumption statistics rather complex.

According to the information collection template, the building primary energy consumption should point out whether the energy consumption covered Heating/Cooling, Lighting, and Plug load. The statistics show that not all the projects covered the Lighting and Plug loads. The primary energy consumption for some projects only refers to Heating/Cooling energy demand.

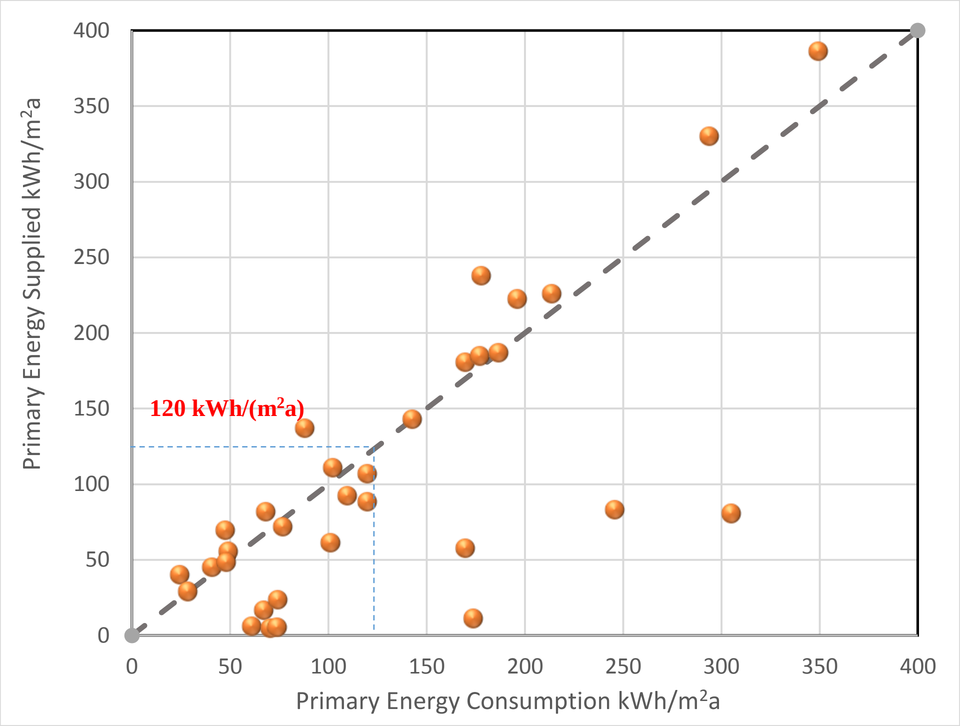


Figure 3-10 Energy balance chart for Net Zero Energy Buildings

CHAPTER 4 Passive Approaches to NZEB

4.1 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[20].

4.1.1 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 4-1 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.

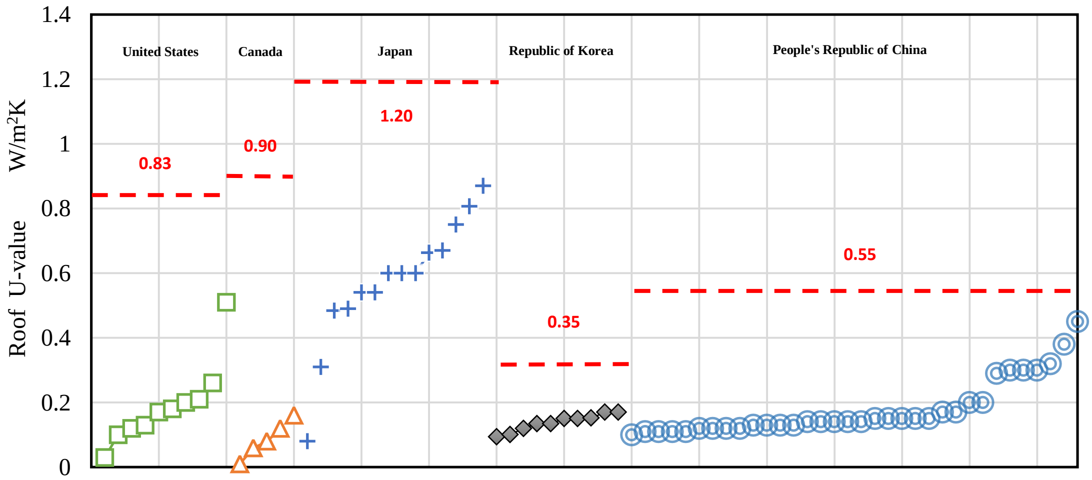


Figure 4-1 Roof U-value of NZEB

Figure 4-2 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.

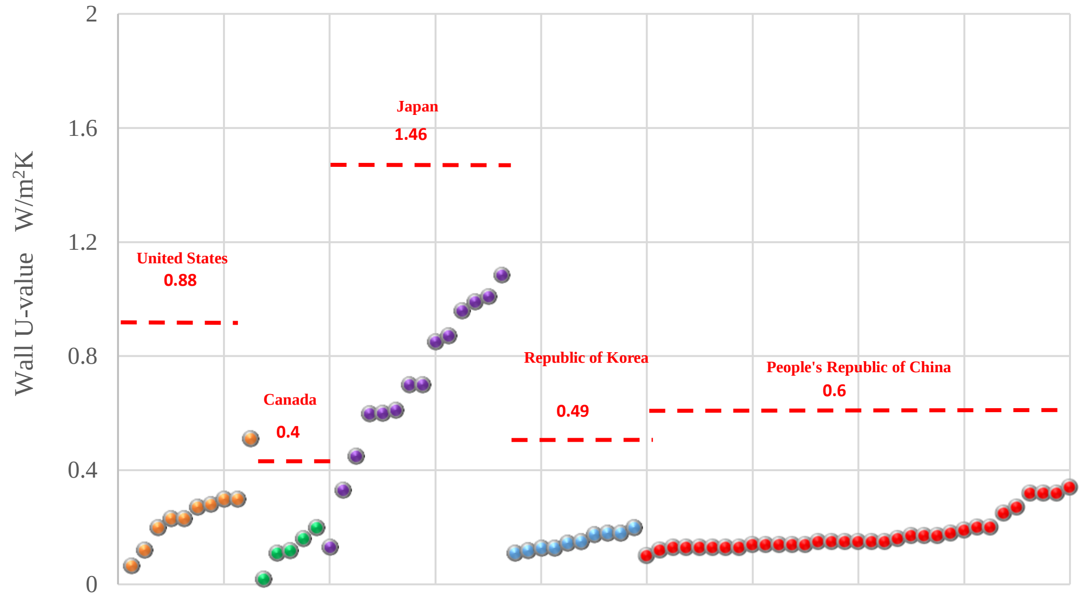


Figure 4-2 Wall U-value of NZEB

4.1.2 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.

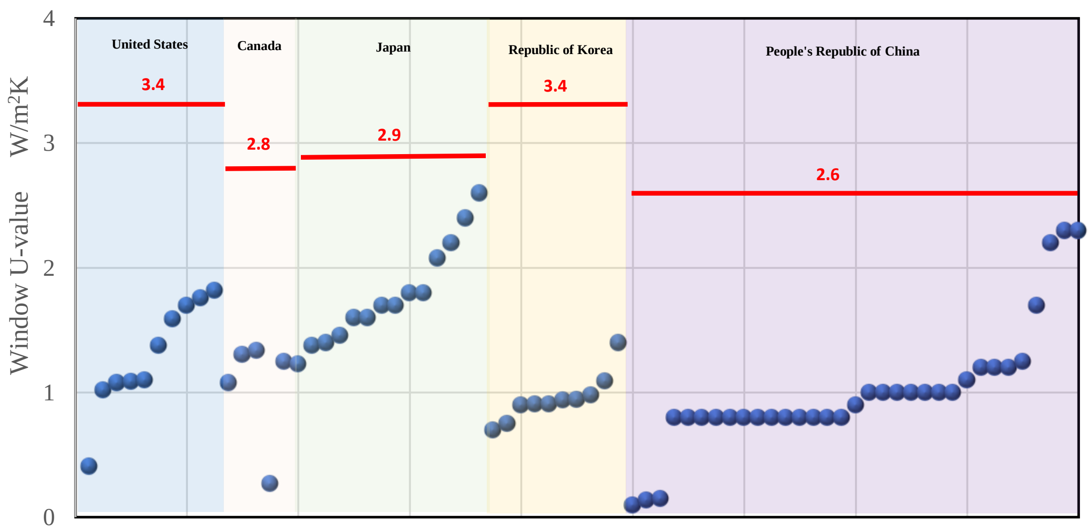


Figure 4-3 Window U-value of NZEB

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 shed heat from the building.

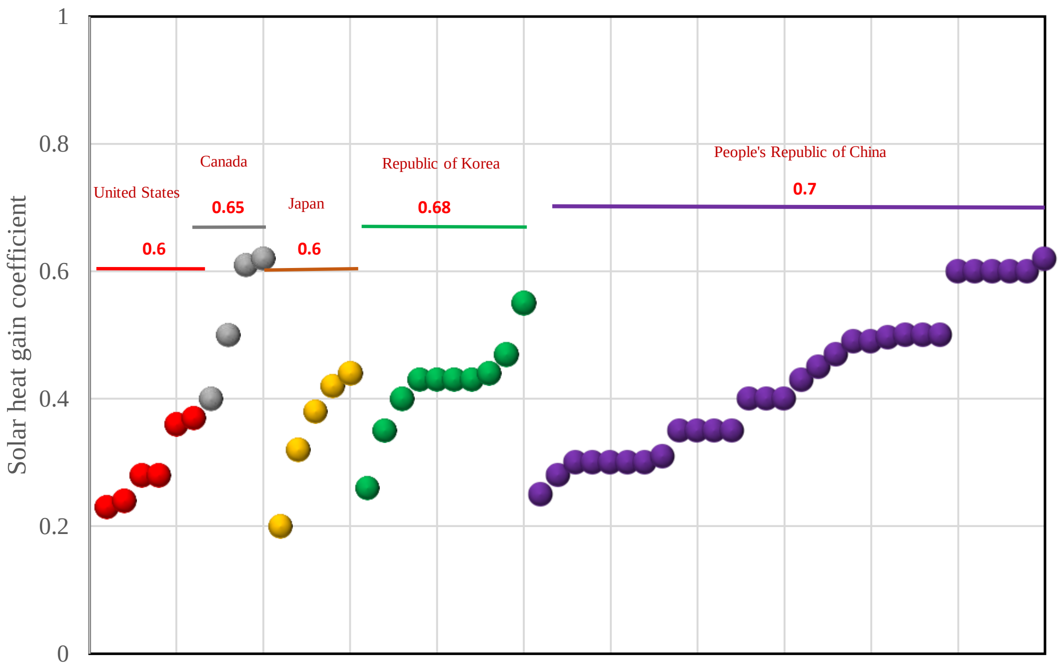


Figure 4-4 Window SHGC value of NZEB

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.

4.1.3 Air tightness

Air tightness is another directive item in NZEB envelope system, a good indication to the extent of air infiltration, the higher air tightness, the lower air infiltration. Air infiltration, like thermal bridging, is essentially thermal holes in the exterior building envelope. In the case of air infiltration, small gaps in the envelope can allow air to pass directly between the interior and exterior environments, causing either heat gain or heat loss, or both. Air movement through the envelope is caused by pressure differences that drive airflow. Pressure differences can be caused by wind, thermal stack effect, and indoor mechanical system, or a combination of these effects.

All NZEB should pass the blower door test apparatus which is a measurement for air infiltration and post-sealing effectiveness evaluation.

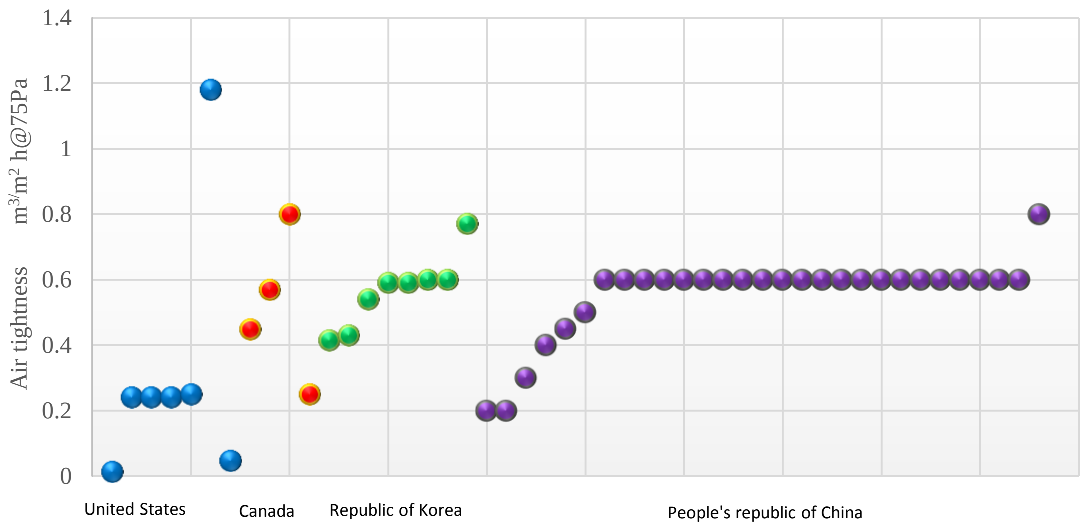


Figure 4-5 Air tightness design

It can be seen from Fig, that very airtight buildings may only have a rate of 0.2 ACH at 50 Pa, and they consequently require mechanical ventilation system to provide fresh air.

For those locations with high heating or cooling degree days, it is more efficient to air seal the buildings and to control the ventilation rate than to allow excessive air leakage. But for those locations with mild climate character, very airtight may not the economic choice.

4.2 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 4-1 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 classified the passive strategies into four types according to the services: heating, cooling, ventilation, and lighting.

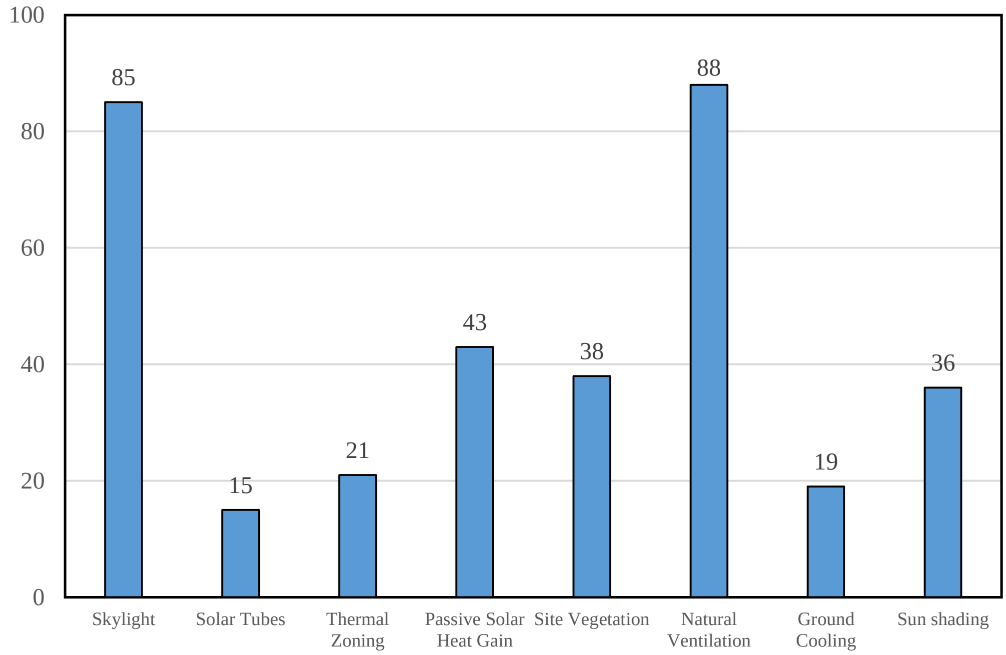


Figure 4-6 Passive Strategies adopted in projects

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.

4.2.1 Passive heating

4.2.1.1 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.

4.2.1.2 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, south-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.

4.2.1.3 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.

4.2.2 Passive cooling

When mentioning passive cooling, the most common way is to prevent solar heat entering the building constructer, 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.

4.2.4 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 restricted by the expensive cost.

【Best Practice】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 4-7 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 light could be achieved on the surface of the table (Figure 4-7) in sunny days by measurement. With the combination of solar tube and artificial lighting, about 20% light energy saving could be achievable.

CHAPTER 5 Active Approaches to NZEB

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.

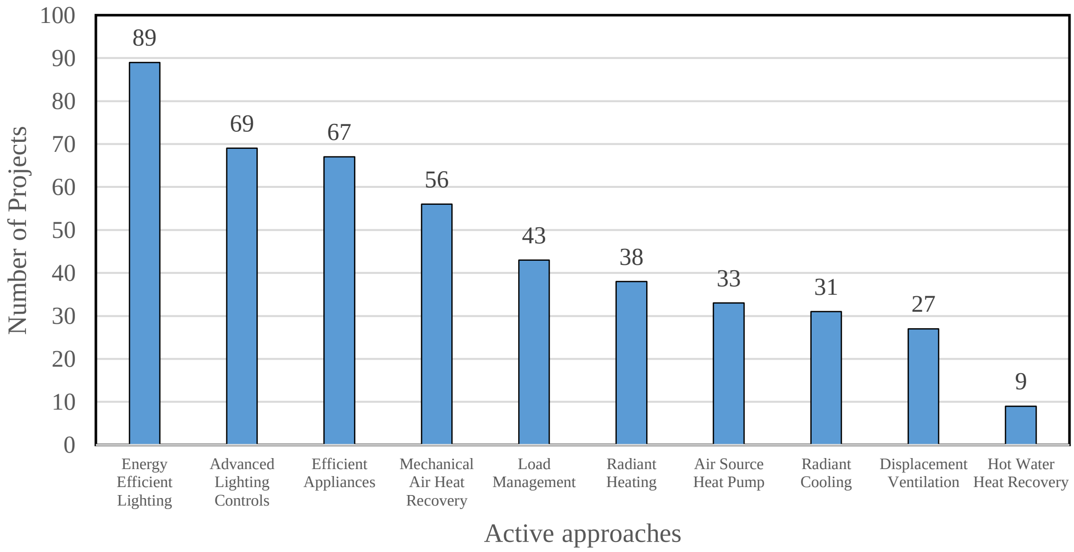


Figure 5-1 Active Strategies adopted in projects

5.1 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^2a) 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:

5.1.1 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 5-2 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 5-3 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 CO2 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 5-4 Pellet boiler and storage in ZCGH[22]

5.1.2 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 5-5). 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 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 5-5 The Eco Terra House. Canada

For now, more efficient heating/cooling equipment are available and becoming more and more cost-efficient. Table 5-1 gives some of the heating technologies together with their cost and efficiencies.

Table 5-1 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

5.2 HVAC system

5.2.1 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. The building is designed with the goal of the greenest commercial building in the world (Figure 5-6).

Figure 5-6 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℃ water from underground tubes to 35℃ for heating the building with radiant heat system (Figure 5-7).

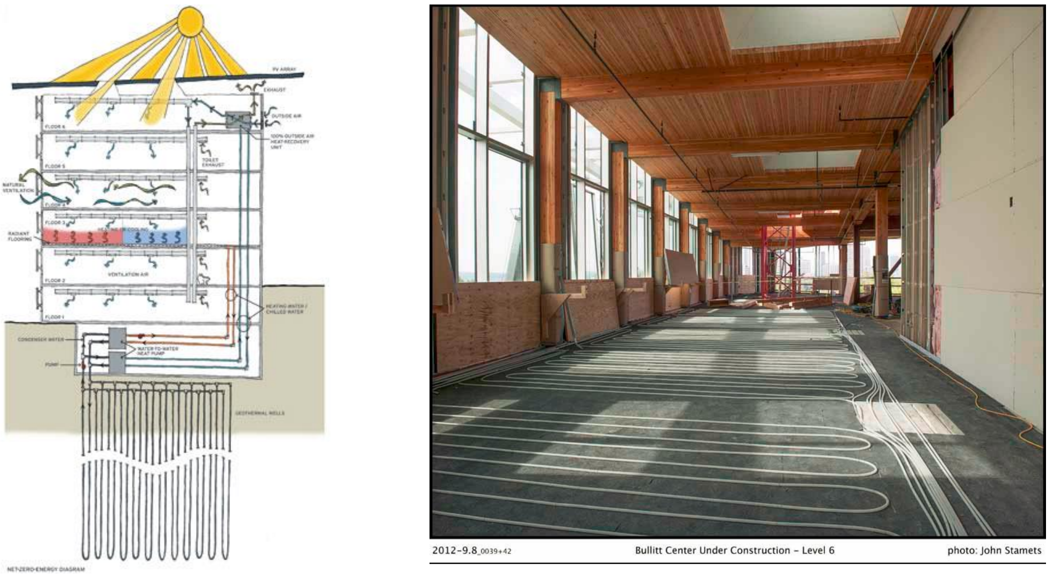


Figure 5-7 The high efficient GSHP and in-floor radiant system in Bullitt Center

5.2.2 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 5-8).

Figure 5-8 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.

5.2.3 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 5-9).

Figure 5-9 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 5-10).

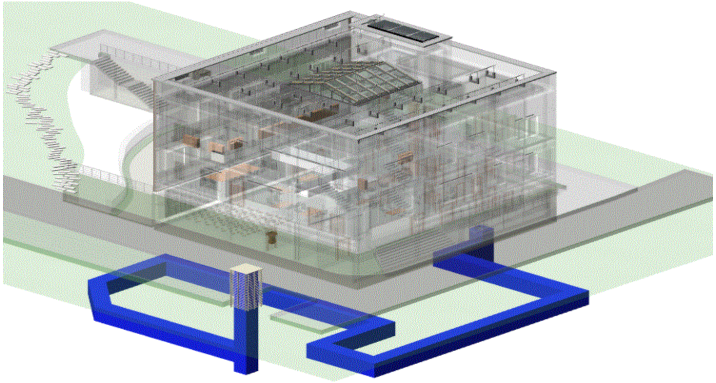


Figure 5-10 The ground cooling system together with the mechanical air heat recovery system

5.3 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 5-11).

Figure 5-11 PV panel system serves public area lighting

5.4 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.

5.4.1 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 5-12).

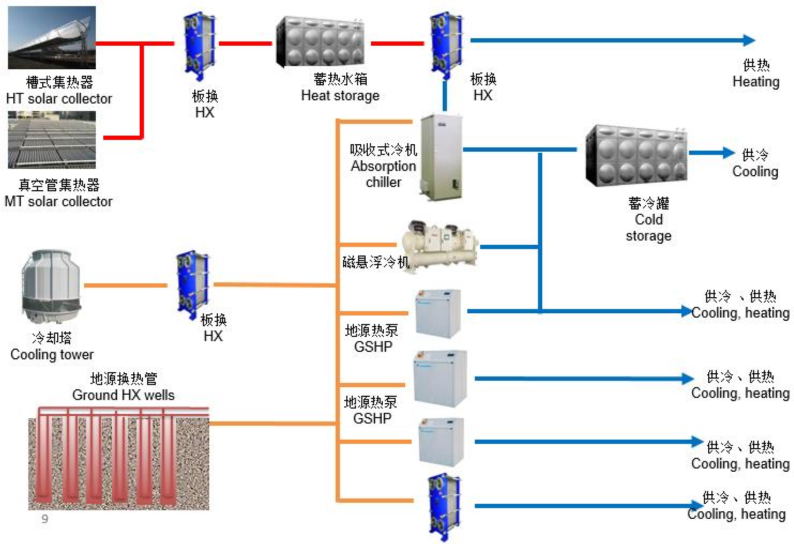


Figure 5-12 Integrated energy system

5.4.2 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 5-13).

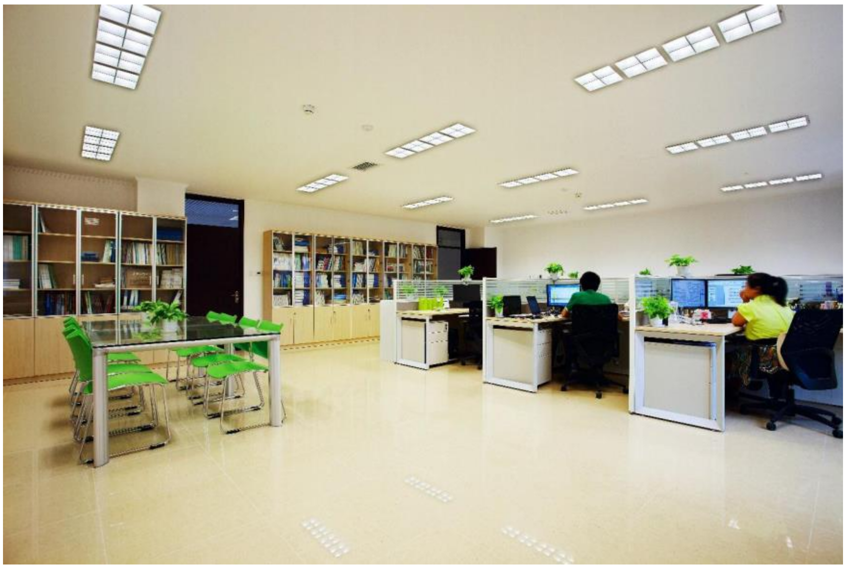


Figure 5-13 Lighting Control System adopted in NZEB in China Academy of Building Research

CHAPTER 6 Renewable Applications in NZEB

The renewable energy generation systems and technologies that integrated in NZEB commonly refer to Solar Power system, solar thermal system, Wind power system, combined heat and power system, and the heat pump system. We take this most common five renewable applications into investigation.

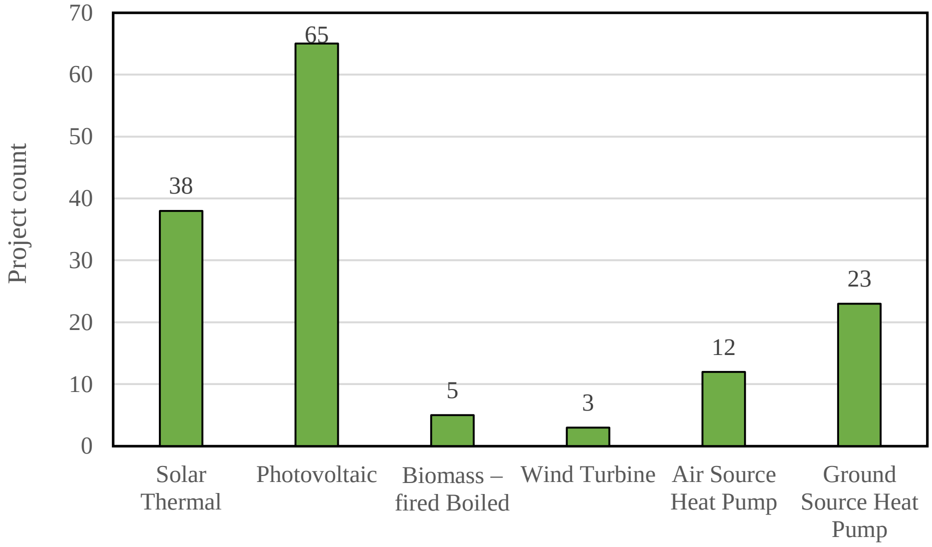


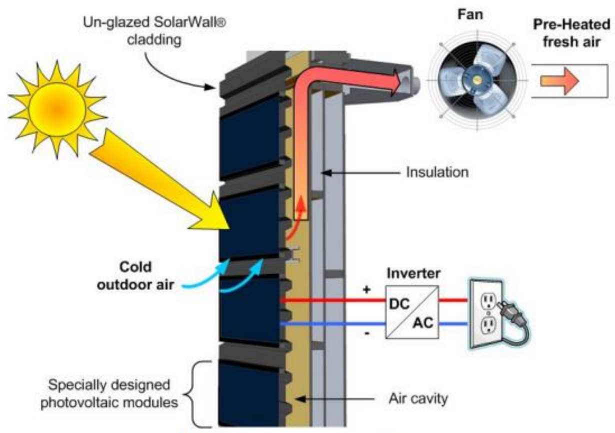
Figure 6-1 Renewable applications in NZEB

6.1 Solar power

Solar power usually refers to building-integrated photovoltaic (BIPV) which is a photovoltaic module that is architecturally and functionally integrated into the building envelope.Comparing to Wind power system, BIPV owns a wider range of applicability.

【Best Practice】*Concordia University's John Molson School of Business building*

The Concordia University's John Molson School of Business building(JMSB) is a 37,000-square-metre 15-storey landmark and its Solar Wall system is a successful example of BIPV application in building envelope.



JMSB PV/T Process Flow Diagram

Figure 6-2 JMSB Solar Wall[27]

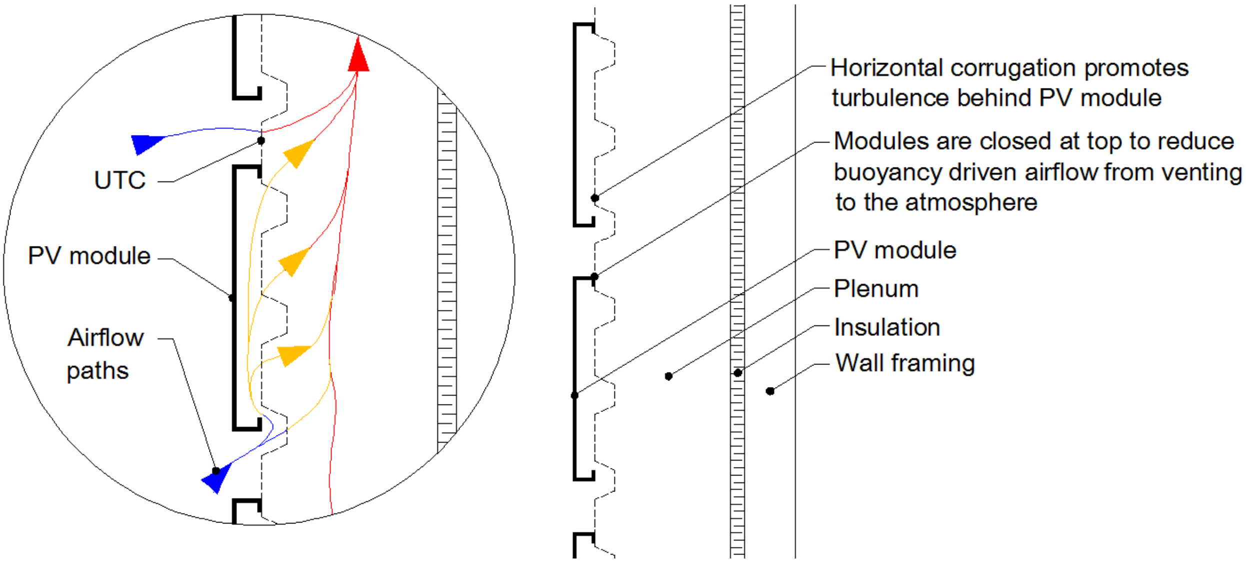


Figure 6-3 Detail showing attachment of PV modules and airflow paths around the bottom frame of a PV module and into the transpired collector.

The John Molson School of Business (JMSB) building-integrated photovoltaic/thermal (BIPV/T) solar system and was the first of its particular configuration in the world when it was built. It consists of specially designed photovoltaic panels optimally combined with perforated wall cladding through which much of the ventilation air of the building is drawn as solar-heated fresh air. Essentially, from one building surface with an area of about 288 square metres, the system generates both solar electricity (up to 25 kilowatts) and solar heat (up to 75 kW of ventilation fresh air heating). The 288m² system also forms the exterior wall layer of the building. This is the first time that a major building-integrated combined solar electric and thermal system has been implemented in a new institutional building in such a prominent location. The system is optimally located because the surface is close to south-facing and the building mechanical room with the ventilation system is right behind the façade so that the solar-heated ventilation air can be utilized in a cost effective manner.

The thermal energy extracted by the BIPV/T system is a contribution of two sources. For about 70% of the solar facade, air is heated by circulating behind the relatively warm solar panels, whereby the Unglazed Transpired Collector (UTC) is used uniquely for PV support and preheated air extraction. The other portion comes from direct solar heat extraction from the exposed UTC surface. In order to maximize the heat recovered from the integrated PV and UTC technologies, many design techniques were used.

The transpired collector used in the prototype is black galvanized steel with a porosity of 0.6% and installed with the corrugations running horizontally to facilitate closing of a gap between the upper frame of the PV panel and the UTC, so as to reduce heat losses by natural convection, while inducing turbulence behind the panels and increasing mixing in comparison to vertically oriented corrugations. Thus, airflow behind the PV modules is possible through the bottom and the sides. The top portion of the JMSB façade was left uncovered to promote buoyancy driven cooling of both the plenum and the modules in summer.

To increase the effective solar absorptance of the panel (including the area between cells), black PV module backsheet was selected in addition to black aluminum frame. Such modifications yield an area-weighted (including framing) average module normal solar absorptance of 92% as compared to 85% for their traditional lighter coloured counterpart, which improves the thermal efficiency.

Another important design parameter was the sizing of the photovoltaic module. Although greatly dictated by the cell sizes available in the industry, a long narrow rectangular module was chosen to reduce vertical temperature stratification of the air in the cavity between the PV panel and the UTC. This reduces the PV operating temperature and facilitates flow of air from behind the PV into the UTC. Finally, the upper edge of the PV modules was mounted directly against the UTC cladding. This was done to minimize the escape of heated air through a potential gap between the top frame of the panel and the transpired collector cladding (Fig.6-3).

The combination of UTC and PV solar technology was optimized using the above techniques and achieved a thermal efficiency of about 40% measured under high solar radiation and wind speeds below 1 m/s in winter time. A DC efficiency of 11.3% was achieved based on measurements in 2011.

【Best Practice】Varennes Net Zero Energy Library

The Varennes library is the first solar net-zero energy institutional building in Canada.

Figure 6-4 Varennes Library (roof BIPV is part BIPV/T).

NSERC SNEBRN, through Concordia University's Centre for Zero Energy Building Studies (CZEBS) provided support and guidance in the early design of the building and helped set the goals such as achieving net-zero energy annual energy consumption through a building-integrated solar system. The library was inaugurated on May 16th, 2016, achieved LEED Gold certification, won an Award of Excellence in Real Estate for Innovation from the Urban Development Institute of Quebec and won an Award of Excellence from the Association of Consulting Engineering Companies of Canada.

The library has two floors and a total floor area of 2017 m^2. The library has a 126 kW roof-mounted building-integrated photovoltaic (BIPV) array with a slope of 38° oriented South to South-East. Over the total 711 m^2 PV area, 428 m^2 is naturally vented through a 150 mm air gap between the PV panels and the metal roofing. The remaining 280 m^2 is fan-assisted and vented through a 75 mm air gap. Heat generated from BIPV/T is connected to Heat Recovery Ventilator to preheat the fresh air. A total of 220 kWh solar heat can be harvested for a typical cold sunny day in February from 110 m^2 BIPV/T section and peak combined thermal plus electrical efficiencies of 60% have been observed. Other features include motorized windows, radiant floor heating, geothermal heat pump, natural cross ventilation, and daylighting control. The operation of the library is intensively instrumented and being studied through a NSERC/Hydro Quebec Industrial Research Chair held by Dr Athienitis. Its interaction with the electricity grid is also being optimized through predictive control.

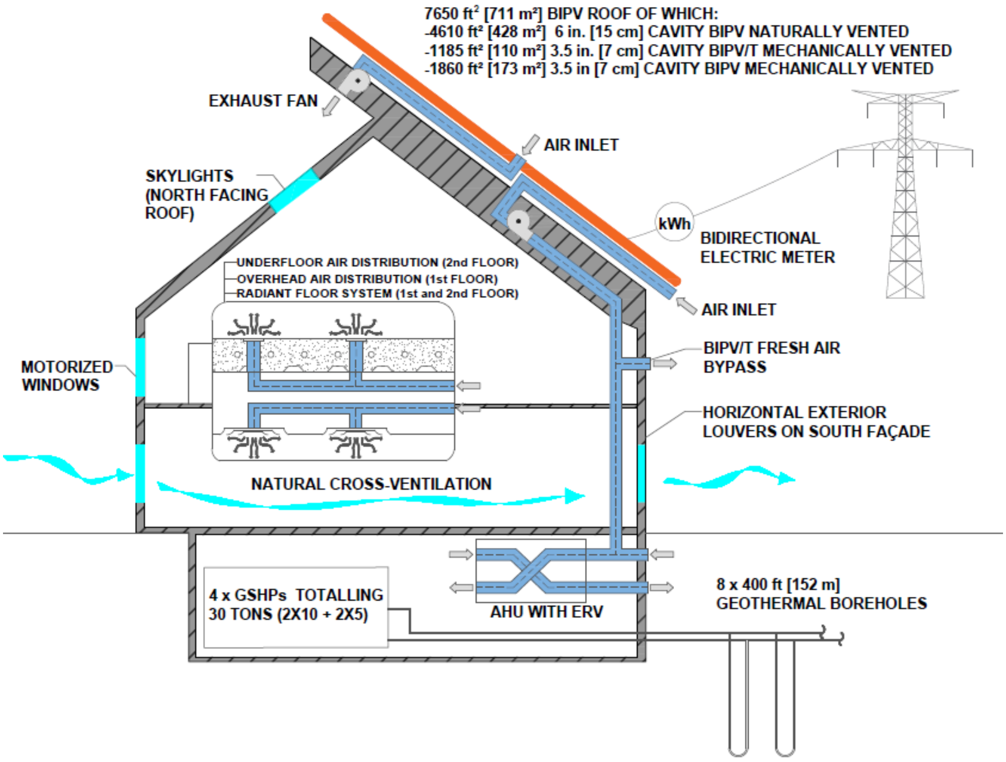


Figure 6-5 Major building energy systems in the Varennes Library illustrated in a building cross section schematic

6.2 Solar thermal

Solar thermal is an efficient way to convert solar energy into useful energy. A solar thermal collector can be over three times more efficient than photovoltaic systems in converting radiant energy into useful energy.

Domestic hot water is one of the most effective and common uses for solar thermal, because the load is typically relatively small and constant year-round.

【Best Practice】Orient Sundar Experts Apartment

The NZEB project Orient Sundar Experts Apartment is located in Hebei Province in China with 8.642 m^2 net floor area (Figure 6-6). The solar thermal domestic hot water system can provide 80L water per person per day (Figure 6-7).

Figure 6-6 Orient Sundar Experts Apartment. China

Figure 6-7 Solar thermal domestic water system

Another application of solar thermal is taken as the heating source of air conditioning system. The solar thermal air- conditioning system in CABR Nearly Zero Energy Building is recognized as the biggest solar thermal air- conditioning system in Asia area, provides the ventilation load, supplemented by a 50kW GSHP unit in summer season. The other 100kW GSHP unit is in place to meet both heating and cooling demand from the radiant terminals for the second and third floor. Coupled with ground source heat pump, the solar collection systems provide direct heating in winter with thermal storage. The organization of the energy plant is shown in Figure 6-8~6-10. Energy plant is very well organized, each equipment and pipe orientation are very well tagged with different colors.

Figure 6-8 High-temperature solar collector

Figure 6-9 Median-temperature solar collector

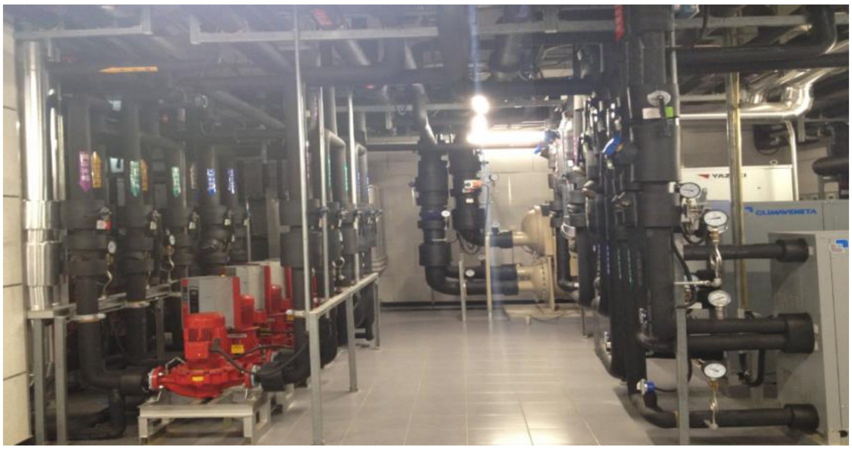


Figure 6-10 Absorption chiller and heat pump system

6.3 Wind

The kinetic energy of the wind is a powerful renewable energy resource that is available all the time—day and night, as long as the wind is blowing. The wind blows moving the turbine and convert the kinetic energy into useful energy and this requires a special range of average wind speed[28].

So it is not possible for all the NZEB to adopt this technology. Among the 100 best practices, only 3 demonstrations adopted wind power system.

【Best Practice】Wind NRG Partners, LLC

Wind NRG Partners, LLC is a new manufacturing facility which is located in Hinesburg, United States. The integrated design was based on using sustainable design as the core organizing principle for the project. The owner, architect, and entire design team, including energy, lighting, and sustainability consultants, shared this commitment and goal. The 10-kW wind turbine can provide the 4,320 m^2 building with 5000 kWh per year.

Figure 6-11 Wind NRG Partners, LLC, United States

6.4 Combined heat and power

Combined heat and power (CHP), also called cogeneration, is the process of taking advantage of the inefficiency built into the process of generating electricity. According to the statistics, nearly 50-60 per cent of the energy will be released directly into atmosphere during power generation process. And the CHP system would lift the efficiency of energy use up to 70-80%.

CHP has been widely used in building heating system worldwide for more than 20 years which is not an innovative technology for NZEB. The application of CHP usually requires the architecture quite near with a power station. But for NZEB, this can turn out to be a boiler-micro grid combined small scale CHP system. Among the 100 best practices, only 1 project adopted this technology which CHP system was design by using gasification pellet boiler connected to Micro Grid.

CHAPTER 7 Economic Analysis of NZEB

The incremental cost of NZEB is for now the biggest obstacle for marketization. Aggressive measures and policies to encourage renovation and energy efficiency improvements need to be implemented to dramatically improve the energy efficiency of existing buildings. This will require significant upfront investment, and their economics will depend heavily on energy prices.

7.1 Financial considerations

Typically, NZEB require reduction of space heating and cooling load through building envelopment improvements, direct solar exposure through good orientation, and energy demand reduction through selection of high efficient appliances and space conditioning equipment before utilization of renewable energy sources can be considered viable.

Despite the added benefits, the incremental cost continues to be a significant deterrent for majority market.

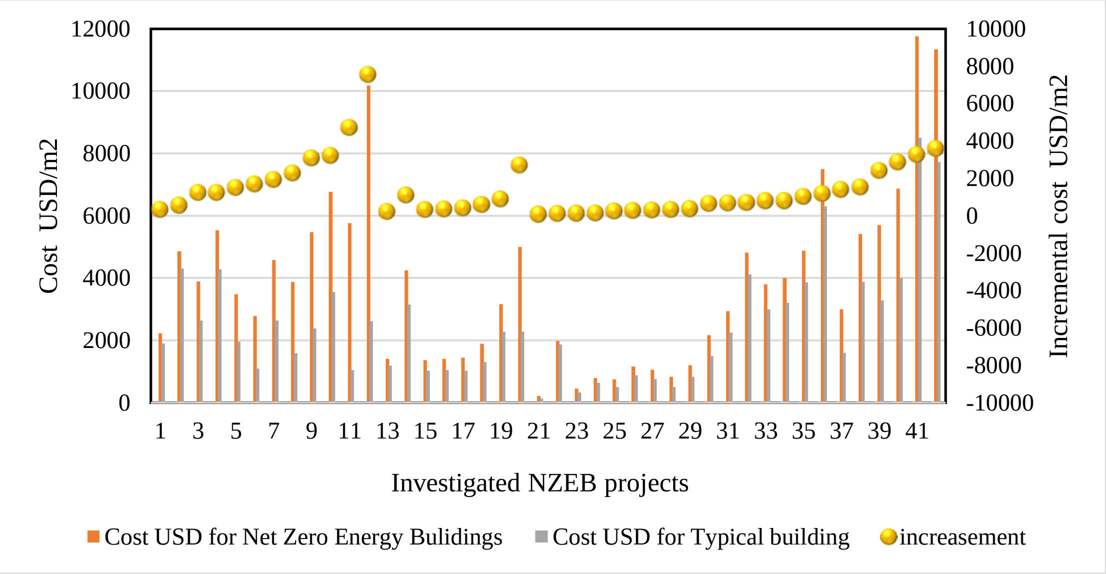


Figure 7-1 Comparison of NZEB cost and standard building cost

According to the investigation, one-third of the project can control the increment cost within 50%, and there are 6 project which increment cost are over 100% of the typical same kind building.

7.2 Incremental cost allocation

Seldom project owners can ignore the incremental cost of NZEB and an explicit analysis on increment cost allocation was conducted during the investigation. Since it is hard for all the project owners to list the allocation, Figure 7-2 show the incremental cost allocation for 22 investigated projects.

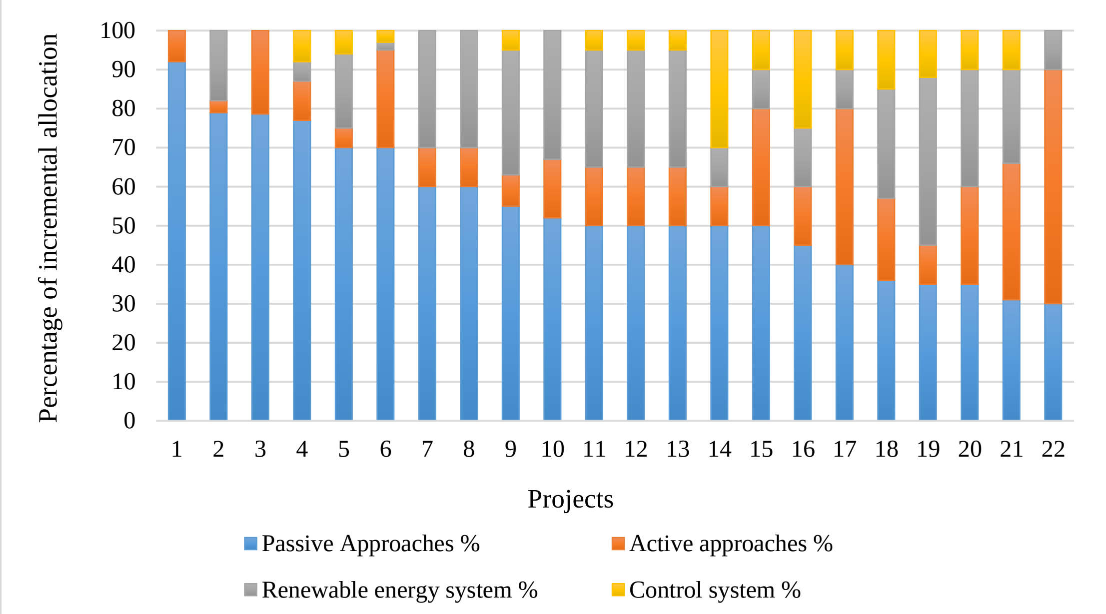


Figure 7-2 Incremental cost allocation

From the allocation investigation, passive approaches accounts for the largest part of the increment cost. This is partially because that passive approaches are usually the basic and first step of NZEB design. Some NZEB project can reach the Net Zero even without renewable energy system or control system.

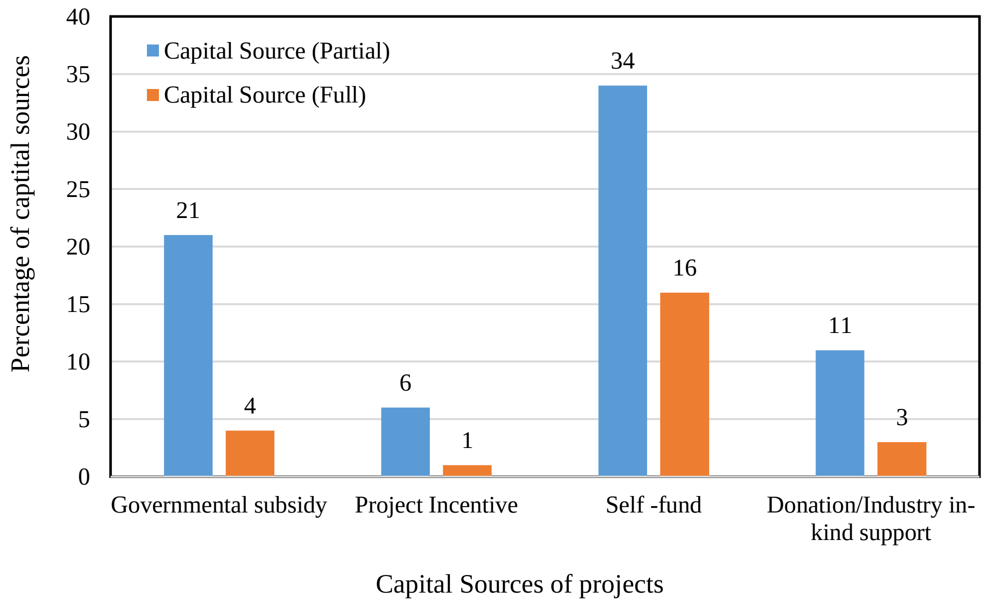


Figure 7-3 Capital Sources of projects

Among the capital sources, self-fund is the major part and 16 projects are fully self-fund support. 21 projects obtain governmental subsidy and four of them are fully governmental subsidy support. Among the 11 donation/industry support projects, 3 of them are totally from the in kind support.

CHAPTER 8 Conculsions

Accounting for around 60 percent of world energy demand, the APEC region is a net energy importer and its demand for energy is increasing rapidly. Recently, some APEC developed economies set the goal to achieve Nearly (Net) Zero Energy Building (NZEB) and already launched national policy and objective in the future 2020, 2030 and 2050.

This report integrated existing information collection forms and templates on NZEB /high performance projects databases and investigation institutes. The APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template was developed upon the integration. Based upon this template, the project conducted an APEC 100 Best NZEB Practices investigation and more than 100 projects was collected. This report shows a comparative analysis of the 100 selected NZEB projects, analyzing on NZEB promoting policies, technical approaches, building increment cost and other NZEB related points.

The investigation shows a good performance on NZEB practices. Among the 100 investigated best projects, 63 projects provided their annual energy consumption and annual renewable energy generation. 28 projects control their annual energy consumption below 120 kWh/(m2a) and 36 projects can achieve the "zero" balance.

During the investigation we find that the difference existed in the energy consumption energy consumption statistics. The total energy consumption investigated in the Japan Projects includes: Heating/Cooling, lighting, and plug load while during the investigation for Canada, Hong Kong, China, and Republic of Korea, the plug load are usually not included. For the projects in China, both of the situations are available. This made the energy consumption statistics hard to compare in the same condition and a unified measurement method on annual energy consumption calculation should be urgently needed.

The U-values of roofs, walls, and windows of the investigated projects are lower than their local building standards. Taking United States for example, the average U-value of investigated NZEB projects is 0.29 W/(m2K) while the standard requirement is 0.88 W/(m2K). The lowest standard requirement is Canada, which is 0.4 W/(m2K) and the average investigated value is 0.22 W/(m2K). During the 33 Chinese projects, the average U-value of external wall is 0.29 W/(m2K) while the requirement in China's latest energy saving standard is 0.6 W/(m2K).

Air tightness is another directive item in NZEB envelope and 92% of the projects achieved the 0.6 ACH at 50Pa requirement.

Among the 100 NZEB best practices, skylight and natural ventilation are the most commonly and economic passive approaches that 85 projects adopted. Passive solar heat gain is considered to be another vital approach for cold climate that 43 project considered this during the design process. Although solar tube and ground cooling are considered to be more expensive and have a limitation on building size, they are still more and more widely used especially in recently projects.

As for active approaches, energy efficient lighting should be the first considered approach since this can greatly reduce energy consumption without big incremental cost. 89 projects adopted efficient lighting and 69 of them adopted advanced lighting control systems. The mechanical air heat recovery system is considered most valuable in extremely hot and cold regions and 56 project applied. Besides, the radiant technologies and heat pump technologies are also treated as the security and necessity leading the building towards net zero.

The incremental cost of NZEB is for now the biggest obstacle for marketization. Aggressive measures and policies to encourage renovation and energy efficiency improvements need to be implemented to dramatically improve the energy efficiency of existing buildings. It’s great to see that during the 100 projects, 21 project are fully or partly governmental-funded and 6 projects acquired incentives as the capital sources. Among the 100 NZEB best practices, 78% of the projects control their incremental cost below 50% and still there are 9 projects which incremental cost is over 90%. With the industrial upgrading, we have every reason to believe that the incremental cost for NZEB will be greatly reduced in the near future and NZEB will be finally the most appropriate way to improve building energy efficiency and reduce carbon emission for building sector.

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Appendix I 100 NZEB Best Practices List

Number	Economy	Project Name	Location	Building Type	Net Floor Area (m^2)
1	Australia	Swanston Academic Building (Building 080)	Melbourne	School	34,325
2	Australia	Pixel Building	Victoria	Museum	1,136
3	Canada	Landmark	Edmonton	Residential	313
4	Canada	Valley Waste ResourceManagement Authority Office	Kentville, NS	Office	743
5	Canada	Varennes NZEB Library	Varennes, QC	Library	2,017
6	Canada	EcoTerra	Eastman, QC	Residential	230
7	Canada	Rideau Residence	Ottawa, Ontario	Residential	329
8	Canada	Solterre ConceptCottage Retreat	Lunenberg, Nova Scotia	Residential	139
9	Canada	John Molson School of Business	Montreal	Office	
10	People's Republic of China	Xingfubao Passive House	Urumqi	Office	7,791
11	People's Republic of China	Cuicheng Disabled Rehabilitation Center	Beijing	Training Center	2,519
12	People's Republic of China	Orient Sundar Experts Apartment	Gaobeidian	Residential	8,016
13	People's Republic of China	The Green Lighthouse	Nanjing	Museum	5,100
14	People's Republic of China	The Garden Home	Tianjin	Residential	10,901
15	People's Republic of China	The Quancheng Park Relief Command Center	Jinan	Multi-purpose	942

Number	Economy	Project Name	Location	Building Type	Net Floor Area (m^2)
16	People's Republic of China	Beihang Science Park	Yantai	Plant	3,042
17	People's Republic of China	Hebei Academy of Building Research Sino-German Passive House	Shijiazhuang	Office	14,527
18	People's Republic of China	Zhongtian Material Depot	Chengde	Multi-purpose	8,315
19	People's Republic of China	Shenyang Jianzhu University Sino-German Passive House	Shenyang	Office	1,600
20	People's Republic of China	Municipal Party School	Weihai	Multi-purpose	15,919
21	People's Republic of China	The City College of Jilin Jianzhu University	Changchun	Multi-purpose	1,187
22	People's Republic of China	CABR Nearly Zero Energy Building	Beijing	Office	4,025
23	People's Republic of China	TENIO Green Office	Tianjin	Office	5,756
24	People's Republic of China	Qingdao Eco Park	Qingdao	Office	13,769
25	People's Republic of China	Shandong Urban Construction Vocational College	Jinan	Multi-purpose	21,428
26	People's Republic of China	Velux Office Building	Langfang	Office	2,014
27	People's Republic of China	Tianyou Green Design Center	Tianjin	Residential	5,756
28	People's Republic of China	Tibet Chengfa Energy saving building material Office	Tibet	Office	2,612

Number	Economy	Project Name	Location	Building Type	Net Floor Area (m^2)
29	People's Republic of China	Zibo Linzi Health nursing home	Zibo	Residential	4,645
30	People's Republic of China	UNIDO Net Zero Energy Building	Lanzhou	Office	13,976
31	People's Republic of China	Wenhui Innovation Center	Tianjin	Hotel	7,919
32	People's Republic of China	Changpeng Car decoration manufacturing Office	Dingzhou	Office	2,859
33	People's Republic of China	Binhai New Area Community Cultural Activity Center	Tianjin	Multi-purpose	9,685
34	People's Republic of China	Tianjin Eco-City Public House Phase II	Tianjin	Residential	5,802
35	People's Republic of China	Chengjian Kingdergardon	Weihai	School	5,647
36	People's Republic of China	The Home of Future	Weifang	Office	2,287
37	People's Republic of China	Zhongsen Honggu Yipin Kindergarden	Nanchang	School	3,882
38	People's Republic of China	Water Front Zero Energy Home	Qinhuangdao	Residential	6,718
39	People's Republic of China	CCT TECH Net Zero Energy Building	Chengdu	Office	4,409
40	People's Republic of China	Shoukai BrownStone Net Zero Energy Building	Xiamen	Residential	1,500

Number	Economy	Project Name	Location	Building Type	Net Floor Area (m^2)
41	People's Republic of China	Sheng Rong Eco Kindergarden	Dongguan	School	3,400
42	People's Republic of China	Landsea Bruck zero Energy building	Huzhou	Office	2,445
43	People's Republic of China	CIFAL Training Center	Zhenjiang	Office	12,786
44	Hong Kong, China	Zero Carbon Building	Hong Kong	Office	3,305
45	Japan	Kawagoe town hall	Mie Pref	Public Service	9,534
46	Japan	Kajima Technical Research Institute building	Tokyo	Institute	9,000
47	Japan	OT building	Tokyo	Office	5,500
48	Japan	SH building	Tokyo	Office	51,800
49	Japan	IN building	Tokyo	Office	104,000
50	Japan	Taisei Sapporo Building	Sapporo	Office	7,000
51	Japan	Itoman City hall	Okinawa Pref.	Public service	15,435
52	Japan	Tochigi Prefectural Government	Tochigi Pref.	Public service	97,954
53	Japan	HL building	Tokyo	Office	7,700
54	Japan	21 Komaba Center for Educational Excellence building	Tokyo	Multi-purpose	4,477

Number	Economy	Project Name	Location	Building Type	Net Floor Area (m^2)
55	Japan	KB building	Kobe	Office	23,500
56	Japan	OI building	Kanagawa Pref.	Office	44,488
57	Japan	Taisei's ZEB	Yokohama	Office	1,277
58	Japan	Unnan City hall	Shimane Pref.	Public service	7,628
59	Japan	MN building	Yamanashi Pref.	OFFICE	8,154
60	Japan	SK building	Tsukuba	Public service	2,258
61	Japan	YM building	Osaka	Multi-purpose	12,563
62	Japan	Hokusetsu Office of The Kansai Electric Power Co., Inc	Osaka	Office	8,453
63	Japan	Akasaka K Tower building	Tokyo	Office	53,777
64	Japan	TC building	Tachikawa City	Office	10,603
65	Republic of Korea	Zero Carbon	Goyang-si	Residential	1,273
66	Republic of Korea	Seoul Energy Dream Center	Seoul	Office	3,762
67	Republic of Korea	All Electric House	Daejeon	Residential	157
68	Republic of Korea	NIER	Inchon	exhibition	1,928
69	Republic of Korea	Geoje Ok-sanli Residential building	Geoje	Residential	93
70	Republic of Korea	Jinchun Zero-Energy Town House (100 Houses)	Jinchun	Residential	145.75 × 100 units

Number	Economy	Project Name	Location	Building Type	Net Floor Area (m^2)
71	Republic of Korea	Odae Mt. Korea National Park kyebangsan Branch Office	Pyeongchang	Office	105
72	Republic of Korea	PHIKO No. 2	Namwon	Residential	99
73	Republic of Korea	On-Yang 6 dong Community Service Center	Asan	Office	1,465
74	Republic of Korea	Seongnam Sampyeong-dong	Seongnam	Office	420
84	People's Republic of China	Post Office	Tianjin	Residential	5,756
75	Singapore	Building and Construction Authority Zero Energy Building Braddell Road Campus	Singapore	Office	4,500
76	Chinese Taipei	ITRI Central Campus Cafeteria	Nantou	Café	793
77	United States	Bullitt Center	Seattle	Office	4,800
78	United States	Chrisney Library	Chrisney	Library	223
79	United States	Environmental Tech. Center Sonoma State	Rohnert Park	Library	204
80	United States	Hawaii Gateway Energy Center	Kailua-Kona	Multi-purpose	334
81	United States	Leslie Shao-Ming Sun Field Station	San Mateo County	School	1,230
82	United States	Oberlin College Lewis Center	Oberlin	School	1,263
83	United States	Omega Center for Sustainable Living	Rhinebeck	Multi-purpose	576
84	United States	The Putney School Net Zero Energy Field House	Putney	School	1,560
85	United States	Science House at the Science Museum of Minnesota	St. Paul	Museum	142

Number	Economy	Project Name	Location	Building Type	Net Floor Area (m^2)
86	United States	Woods Hole Research Center	Falmouth	Library	1,784
87	United States	Wind NRG Partners Manufacturing Facility	Hinesburg, VT	Multi-purpose	4,320
88	United States	NREL Wind Site Entrance Building (SEB)	Lousiville, CO	Multi-purpose	15
89	United States	Eco Office	Atlanta, GA	Multi-purpose	938
90	United States	Doyle Conservation Center (DCC)	Leominster, MA	Multi-purpose	2,043
91	United States	Aldo Leopold Legacy Center	Baraboo, WI	Multi-purpose	1,104
92	United States	Challengers Tennis Club	Los Angeles, CA	Stadium	325
93	United States	Magnify Credit Union - South Lakeland	Lakeland, FL	Multi-purpose	385
94	United States	NREL Science and Technology Facility	Golden, CO	Office	6,628
95	United States	Jane D'Aza Convent House of Formation	San Rafael	Residential	576
96	United States	Nueva School	Hillsborough, CA	School	2,508
97	United States	UT School of Nursing and Student Center	Houston, TX	School/Laboratory	18,116
98	United States	Rice Fergus Miller Office	Bremerton, WA	Office	3,344
99	United States	Sidwell Friends Middle School	Washington, DC	School	6,707
100	United States	Claiborne & Churchill Winery	San Luis Obispo, CA	Store Retail	240

Appendix II Figures of Best Practices

Appendix II here gives out the cases that approved to disclosed.

	
No.1 AUS- Swanston Academic Building	No.2 AUS- Pixel Building
	
No.5 CAN- Varennes NZEB Library	No.7 CAN- Rideau Residence
	
No.8 CAN- Solterre Concept Cottage Retreat	No.9 CAN-John Molson School of Business
	
No.10 CHN- Xingfubao Passive House	No.11 CHN- Cuicheng Disabled Rehabilitation Center

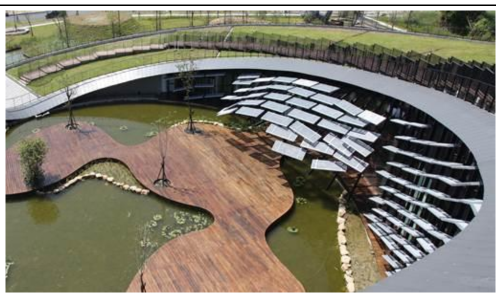
	
No.12 CHN- Orient Sundar Experts Apartment	No.13 CHN-The Green Lighthouse
	
No.14 CHN-The Garden Home	No.15 CHN-The Quancheng Park Relief Command Center
	
No.16 CHN- Beihang Science Park	No.17 CHN- Hebei Academy of Building Research Sino-German Passive House
	
No.18 CHN- Zhongtian Material Depot	No.19 CHN- Shenyang Jianzhu University Sino-German Passive House

	
No.20 CHN- Municipal Party School	No.21 CHN- The City College of Jilin Jianzhu University
	
No.22 CHN- CABR Nearly Zero Energy Building	No.23 CHN- TENIO Green Office
	
No.24 CHN- Qingdao Eco Park	No.25 CHN- Velux Office Building
	
No.28 CHN- Tibet Chengfa Energy saving building material Office	No.29 CHN- Zibo Linzi Health nursing home

	
No.31 CHN- Wenhui Innovation Center	No.32 CHN- Changpeng Car decoration manufacturing Office
	
No.33 CHN- Binhai New Area Community Cultural Activity Center	No.34 CHN- Tianjin Eco-City Public House Phase II
	
No.35 CHN- Chengjian Kingdergardon	No.36 CHN- The Home of Future
	
No.37 CHN- Zhongsen Honggu Yipin Kindergarden	No.38 CHN- Water Front Zero Energy Home

	
No.40 CHN- Shoukai BrownStone Net Zero Energy Building	No.43 CHN- CIFAL Training Center
	
No.44 HK-Zero Carbon Building	No.45 JP-Kawagoe town hall
	
No.46 JP- Kajima Technical Research Institute building	No. 50 JP-Taisei Sapporo Building
	
No. 51 JP-Itoman City hall	No.54 JP-21 Komaba Center for Educational Excellence Building

	
No. 57 JP-Taisei's ZEB	No.58 JP-Unnan City hall
	
No.62 JP-Hokusetsu Office of Kansai Electric Power Co., Inc.	No. 63 JP-Akasaka K tower building
	
No. 65 KOR-Zero Carbon Green Home	No.66 KOR- Seoul Energy Dream Center
	
No.67 KOR- All Electric House	No.68 KOR- NIER NZEB

	
No.69 KOR- Geoje Ok-sanli Residential building	No.70 KOR-Jinchun Zero-Energy Town House (100 Houses)
	
No.71 KOR-Odae Mt. Korea National Park kyebangsan Branch Office	No. 72 KOR-PHIKO No. 2
	
No.73 KOR-On-Yang 6 dong Community Service Center	No.74 KOR-Seongnam Sampyeong-dong PostOffice
	
No.75 SIN- Building and Construction Authority Zero Energy Building Braddell Road Campus	No.76 TPE- ITRI Central Campus Cafeteria

	
No.77 US-Bullitt Center	No.78 US- Chrisney Library
	
No.79 US-Environmental Tech Center Sonoma State	No.80 US- Hawaii Gateway Energy Center
	
No.81 US- Leslie Shao-Ming Sun Field Station	No.82 US- Oberlin College Lewis Center
	
No.83 US- Omega Center for Sustainable Living	No.84 US- The Putney School Net Zero Energy Field House

	
No.85 US- Science House at the Science Museum of Minnesota	No.87 US- Wind NRG Partners Manufacturing Facility
	
No.88 US- NREL Wind Site Entrance Building (SEB)	No.90 US- Doyle Conservation Center (DCC)
	
No.91 US- Aldo Leopold Legacy Center	No.92 US- Challengers Tennis Club
	
No.93 US- Magnify Credit Union - South Lakeland	No.94 US- NREL Science and Technology Facility

	
No.95 US- Jane D'Aza Convent House of Formation	No.96 US- Nueva School
	
No.97 US- UT School of Nursing and Student Center	No.99 US- Sidwell Friends Middle School
	
No.100 US- Claiborne & Churchill Winery	

Appendix III Selected Best Practices information template

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Swanston Academic Building	Location (City)	Melbourne, Victoria Australia
Building Type	☐Residential ☐Office ☐School ☐Others (Please Specify)_Higher Education		
Net Floor Area（m^2）	34,325.41 m2	Treated floor area（m^2）	21,578.50 m2
Number of storeys	15	Completion Date	July 2012
Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） X Renewable energy system（ %） ☐Control system（ %） 25% reduction target by 2020，50% onsite，30% through EPCs and 20% offsets		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） X Self-fund（ %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）	**8.0**	
	Annual Cooling Demand（kWh/m^2a）	**2.5**	
	Primary Energy Consumption kWh/(m^2)	**49.6**	
	Primary Energy Consumption Including:**x**Heating/Cooling **x**Lighting **x**Plug		
Building energy codes or standards	National Construction code of Australia		

Energy saving approaches（Yes for√）				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	√	√		√
	Others (Please Specify)	Mixed mode ventilation in student commons (portals) Under floor air distribution in lecture theatres 80kL Rainwater tank		

		10kL Greywater tank				
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery	
	√	√	√	√	√	
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery	
	√	√	√	√	√	
	Other (Please Specify)	BMS is connected to the room bookings so conditioning will not operate unless rooms are booked, including class rooms				

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Valley Waste Resource Management Authority Office	Location (City)	Kentville, NS
Building Type	☐Residential ■Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day	4130	Cooling Degree Day	
Net Floor Area (m^2)	743	Treated floor area (m^2)	623
Number of storeys	2F/ BF	Completion Date	June, 2012
Incremental Cost Allocation (%)	☐Passive approaches (4.8 %) ☐Active approaches (%) ☐Renewable energy system (%) ☐Control system (%)		
Source of Incremental Cost	☐Government Subsidy (%) ☐Project Incentive (%) ☐Self-fund (%) ☐Donation/Industry in-kind support (%)		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand (kWh/m^2a)	**14.4**	**32.1**
	Annual Cooling Demand (kWh/m^2a)		
	Primary Energy Consumption kWh/(m²)	**44**	
	Source to Site Conversion Factor (Electri	**2.7**	
	Primary Energy Consumption Including:■Heating/Cooling ■Lighting■Plug		

Energy saving approaches（Yes for√）					
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain	
	X		X	X	
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading	
	X	X			
	Others	Passive solar design			
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	X	X	X		89% Latent and Sensible
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
				X	

APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template

Basic Information			
Building Name	Bibliothèque de Varennes	Location (City)	Varennes, QC
Building Type	☐Residential ☐Office ☐School ■Others (Please Specify)_Library________		
Heating Degree Day	5151 (<18°C)	Cooling Degree Day	95 (>18°C)
Net Floor Area（m^2	2017	Treated floor area（m^2）	
Number of storeys	2F/ BF	Completion Date	December, 2014
Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	■Government Subsidy（ 35 %） ☐Project Incentive（ %） ■Self-fund（ 57 %） ■Donation/Industry in-kind support（ 8 %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）	**19**	**153**

	Annual Cooling Demand (kWh/m²a)	**5**	**19**
	Primary Energy Consumption kWh/(m²)	**77**	**348**
	Source to Site Conversion Factor (Electrici	**1.5 (hydro and wind)**	
	Primary Energy Consumption Including: ■Heating/Cooling ■Lighting ■Plug		
Building energy codes or standards	**National Building Code of Canada; National Energy Code for Buildings**		

Energy saving approaches (Yes for√)

Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	X		X	X
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	X	X		X

Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	X	X (*)	X		X
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	X	X	X	X	
	Other (Please Specify)	(*) DALI - Digital Addressable Lighting Interface • BIPV/T system with heat recovery supplementing fresh air pre-heat • CO_2 based ventilation • condenser heat from heat pump to DHW tank			

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information

Building Name	EcoTerra	Location (City)	Eastman, QC
Building Type	■ Residential ☐Office ☐School ☐Others (Please Specify)_________		
Heating Degree Day	5151 (<18°C)	Cooling Degree Day	95 (>18°C)
Net Floor Area (m²	230	Treated floor area (m²)	210
Number of storeys	2F/ BF	Completion Date	August, 2008
Incremental Cost Allocation (%)	☐Passive approaches (%) ☐Active approaches (%) ☐Renewable energy system (%) ☐Control system (%)		
Source of Incremental Cost	☐Government Subsidy (%) ☐Project Incentive (%)		

	☐Self-fund（ %） ☐Donation/Industry in-kind support（ %）				
Key Technical Indexes					
Energy consumption	**Energy Consumption Targets**			**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m²a）			**42**	**122**
	Annual Cooling Demand（kWh/m²a）			**0**	**3**
	Primary Energy Consumption kWh/(m²)			**52**	**183**
	Source to Site Conversion Factor (Electricity)			**1.5 (hydro and wind)**	
	Primary Energy Consumption Including:■ Heating/Cooling■ Lighting■Plug				
Building energy codes or standards	**National Building Code of Canada**				
Energy saving approaches（Yes for√）					
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain	
			X	X	
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading	
		X	X	X	
	Others	Thermal mass			
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	X		X	X	X
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	X	X			
	Other (Please Specify)	• **BIPV/T roof connected to a concrete slab for active thermal charging/discharging** • **Motorized exterior awnings**			

APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template

Basic Information			
Building Name	Rideau Residence	Location (City)	Ottawa, Ontario
Building Type	■Residential ☐Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day	4059	Cooling Degree Day	1317
Net Floor Area	329	Treated floor area	

(m^2)		(m^2)	
Number of storeys	2 F/ BF	Completion Date	Sept, 2014
Incremental Cost Allocation (%)	☐Passive approaches (%) ☐Active approaches (%) ☐Renewable energy system (%) ☐Control system (%)		
Source of Incremental Cost	☐Government Subsidy (%) ☐Project Incentive (%) ■Self-fund (%) ☐Donation/Industry in-kind support (%)		

Key Technical Indexes

	Energy Consumption Targets	Design Value	Average value for typical
Energy consumption	Annual Heating Demand (kWh/m^2a)	**14.72**	
	Annual Cooling Demand (kWh/m^2a)	**7.7**	
	Primary Energy Consumption $kWh/(m^2)$	**90**	
	Source to Site Conversion Factor (Electricity)	**3.3**	
	Primary Energy Consumption Including: ■Heating/Cooling ■Lighting ■Plug		
Building energy codes or standards	**Passive House Standard / LEED Platinum for Homes**		

Energy saving approaches (Yes for√)

Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	X (*)			
	Others	(*) Green roof		

Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Solterre Concept Cottage Retreat	Location (City)	Lunenberg, Nova Scotia
Building Type	☐Residential ☐Office ☐School ☐Others (Please Specify)_________		
Heating Degree Day	4518	Cooling Degree Day	813
Net Floor Area（m²	139	Treated floor area（m²）	
Number of storeys	1 F/ BF	Completion Date	Oct, 2012
Incremental Cost Allocation（%）	■Passive approaches（ 7.7 %） ☐Active approaches（ %） ■Renewable energy system（14.0 %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ■Project Incentive（ %） ☐Self-fund（ %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m²a）	**17.35 kWh/m²**	
	Annual Cooling Demand（kWh/m²a）		
	Primary Energy Consumption kWh/(m²)	**13 kWh - Electricity** **13.6 ekWh - Wood** **4.5 ekWh - Propane**	**273kWh**
	ource to Site Conversion Factor (Electricity)	**N/A (off-grid)**	
	Primary Energy Consumption Including: 1800 kWh/year ■Heating/Cooling ■Lighting ■Plug 70 litres propane / year		
Building energy codes or standards	**Passive House Standard / LEED Platinum for Homes**		

Energy saving approaches（Yes for√）				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	X		X	X
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	X		X	Trees (east & west)

Active Approaches	Energy Efficient	Advanced Lighting	Efficient Appliances	Load Management	Mechanical Air Heat Recovery

	Lighting	Controls			
	X		X		X
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
					X

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Xingfubao Passive House	Location (City)	Urumqi
Building Type	☐Residential ☐ √ Office ☐School ☐Others (Please Specify)_________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area (m^2)	7791.03m^2	Treated floor area (m^2)	6209.3 m^2
Number of storeys	6F/ 2 BF	Completion Date	2014.12
3Incremental Cost Allocation (%)	☐Passive approaches (75.66 %) ☐Active approaches (1 %) ☐Renewable energy system (5 %) ☐Control system (%)		
Source of Incremental Cost	☐Government Subsidy (%) ☐Project Incentive (%) ☐ √ Self-fund (%) ☐Donation/Industry in-kind support (%)		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand (kWh/m^2a)	14.1	15
	Annual Cooling Demand (kWh/m^2a)	3.0	15
	Primary Energy Consumption kWh/(m^2)	54	120
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches (Yes for√)				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√			√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
		√		√

Active Approaches	Energy Efficient	Advanced Lighting	Efficient Appliances	Load Management	Mechanical Air Heat Recovery

	Lighting	Controls			
	√	√	√		√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
		√	√		

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information							
Building Name	Cuicheng Disabled Rehabilitation Center		Location (City)		Beijing		
Building Type	☐Residential ☐ √ Office ☐School ☐Others (Please Specify)_________						
2470	2470		Cooling Degree Day				
Net Floor Area（m^2）	2519		Treated floor area（m^2）		1316		
Number of storeys	3F/ 1 BF		Completion Date		2016.10		
3Incremental Cost Allocation（%）	☐Passive approaches (79 %) ☐Active approaches (3 %) ☐Renewable energy system (18 %) ☐Control system (%)						
Source of Incremental Cost	☐Government Subsidy (%) ☐Project Incentive (%) ☐ √ Self-fund (%) ☐Donation/Industry in-kind support (%)						
Key Technical Indexes							
Energy consumption	**Energy Consumption Targets**			**Design Value**		**Average value for typical**	
	Annual Heating Demand（kWh/m^{2}a）			12			
	Annual Cooling Demand（kWh/m^{2}a）			19			
	Primary Energy Consumption kWh/(m²)			72			
	Source to Site Conversion Factor (Electricity)						
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug						
Energy saving approaches（Yes for√）							
Passive Approaches	Skylight	Solar Tubes		Thermal Zoning		Passive Solar Heat Gain	
	√			√			
	Site Vegetation	Natural Ventilation		Ground Cooling		Sun shading	
		√				√	
	Energy	Advanced	Efficient		Load		Mechanical Air Heat

<table>
<tr><td rowspan="4">Active Approaches</td><td>Efficient Lighting</td><td>Lighting Controls</td><td>Appliances</td><td>Management</td><td>Recovery</td></tr>
<tr><td>√</td><td>√</td><td>√</td><td></td><td>√</td></tr>
<tr><td>Displacement Ventilation</td><td>Radiant Heating</td><td>Radiant Cooling</td><td>Air Source Heat Pump</td><td>Hot Water Heat Recovery</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
</table>

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

<table>
<tr><td colspan="4">Basic Information</td></tr>
<tr><td>Building Name</td><td>Orient Sundar Experts Apartment</td><td>Location (City)</td><td>Gaobeidian</td></tr>
<tr><td>Building Type</td><td colspan="3">☐ √ Residential ☐Office ☐School ☐Others (Please Specify)__________</td></tr>
<tr><td>Heating Degree Day</td><td></td><td>Cooling Degree Day</td><td></td></tr>
<tr><td>Net Floor Area（m²）</td><td>8016</td><td>Treated floor area（m²）</td><td>5475</td></tr>
<tr><td>Number of storeys</td><td>9F/ 1 BF</td><td>Completion Date</td><td>2015.09</td></tr>
<tr><td>3Incremental Cost Allocation（%）</td><td colspan="3">☐Passive approaches（ 80 %） ☐Active approaches（ %）
☐Renewable energy system（ 5 %） ☐Control system（ 15 %）</td></tr>
<tr><td>Source of Incremental Cost</td><td colspan="3">☐Government Subsidy（ %） ☐Project Incentive（ %）
☐ √ Self-fund（100 %） ☐Donation/Industry in-kind support（ %）</td></tr>
</table>

<table>
<tr><td colspan="4">Key Technical Indexes</td></tr>
<tr><td rowspan="6">Energy consumption</td><td>Energy Consumption Targets</td><td>Design Value</td><td>Average value for typical</td></tr>
<tr><td>Annual Heating Demand（kWh/m²a）</td><td>13.8</td><td>15</td></tr>
<tr><td>Annual Cooling Demand（kWh/m²a）</td><td>9.93</td><td>15</td></tr>
<tr><td>Primary Energy Consumption kWh/(m²)</td><td>98.49</td><td>120</td></tr>
<tr><td>Source to Site Conversion Factor (Electricity)</td><td colspan="2"></td></tr>
<tr><td colspan="3">Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug</td></tr>
<tr><td colspan="4">Energy saving approaches（Yes for√）</td></tr>
</table>

Passive Approaches	Skylight	Solar Tubes		Thermal Zoning	Passive Solar Heat Gain
	√				
	Site Vegetation	Natural Ventilation		Ground Cooling	Sun shading
	√	√			√
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√		√		√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
				√	

APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template

Basic Information			
Building Name	Lighthouse	Location (City)	Nanjing
Building Type	☐Residential ☐ √ Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day	1155	Cooling Degree Day	
Net Floor Area (m^2)	5100	Treated floor area (m^2)	
Number of storeys	3.5F/ 1 BF	Completion Date	2015.07
3Incremental Cost Allocation (%)	☐Passive approaches (36 %) ☐Active approaches (21 %) ☐Renewable energy system (28 %) ☐Control system (15 %)		
Source of Incremental Cost	☐Government Subsidy (%) ☐Project Incentive (%) ☐ √ Self-fund (%) ☐Donation/Industry in-kind support (%)		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand (kWh/m^2a)	**27**	
	Annual Cooling Demand (kWh/m^2a)	**72**	

	Primary Energy Consumption kWh/(m²)	**25**		
	Source to Site Conversion Factor (Electricity)			
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug			

Energy saving approaches（Yes for√）				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√			√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
		√		√

Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√	√	√	√	
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	Other				

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	The Garden Home	Location (City)	Tianjin
Building Type	☐Residential ☐ √Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area（m²）	10901	Treated floor area（m²）	7365
Number of storeys	30F/ 1 BF	Completion Date	2017.12
3Incremental Cost Allocation（%）	☐Passive approaches（ 40 %） ☐Active approaches（ 40 %） ☐Renewable energy system（ 10 %） ☐Control system（ 10 %）		
Source of Incremental Cost	☐Government Subsidy（ 3 %） ☐Project Incentive（ %） ☐ √Self-fund（97 %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）	**15**	**15**
	Annual Cooling Demand（kWh/m^2a）	**23**	**23**
	Primary Energy Consumption kWh/(m^2)	**119**	**120**
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches（Yes for√）

Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√			√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
		√		√

Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	The Quancheng Park Relief Command Center	Location (City)	Jinan
Building Type	☐Residential ☐ √ Office ☐School ☐Others (Please Specify)_________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area（m^2）	945	Treated floor area（m^2）	943
Number of storeys	3F/ 1 BF	Completion Date	2016.02
3Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐ √ Self-fund（ %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）	**0.39**	**10**
	Annual Cooling Demand（kWh/m^2a）	**13.10**	**25**
	Primary Energy Consumption kWh/(m^2)	**41.54**	**120**
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches（Yes for√）				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√	√		√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	√	√	√	√

	Energy	Advanced	Efficient	Load	Mechanical Air Heat

Active Approaches	Efficient Lighting	Lighting Controls	Appliances	Management	Recovery
	√		√	√	√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
			√	√	

APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template

Basic Information			
Building Name	Beihang Science Park	Location (City)	Yantai
Building Type	☐Residential ☐ √ Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area（m²）	3041	Treated floor area（m²）	3006
Number of storeys	4F/ BF	Completion Date	2017.08
3Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐ √ Self-fund（ %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m²a）	**6.41**	**9.81**
	Annual Cooling Demand（kWh/m²a）	**10.19**	**11.13**
	Primary Energy Consumption kWh/(m²)		
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches（Yes for√）				
	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain

Passive Approaches	√				
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading	
		√		√	
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√		√		√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
		√	√		

APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template

Basic Information				
Building Name	Hebei Academy of Building Research Sino-German Passive House	Location (City)	Shijiazhuang	
Building Type	☐Residential ☐ √ Office ☐School ☐Others (Please Specify)_________			
Heating Degree Day		Cooling Degree Day		
Net Floor Area（m^2）	14527	Treated floor area（m^2）	11954	
Number of storeys	6F/ 1 BF	Completion Date	2012.06	
3Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）			
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐ √ Self-fund（ %） ☐Donation/Industry in-kind support（ %）			
Key Technical Indexes				
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**	
	Annual Heating Demand（kWh/m^2a）	**10.28**		

	Annual Cooling Demand（kWh/m²a）	**13.08**	
	Primary Energy Consumption kWh/(m²)	**94.02**	
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches（Yes for√）					
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain	
	√	√		√	
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading	
		√		√	
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√		√		√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	√	√	√		

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Zhongtian Material Depot	Location (City)	Chengde
Building Type	☐Residential ☐ √Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area（m²）	8315	Treated floor area（m²）	6688
Number of storeys	5F/ 1BF	Completion Date	2015.11
3Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %）		

<table>
<tr><td></td><td colspan="5">☐ √ Self-fund （ % ） ☐Donation/Industry in-kind support （ % ）</td></tr>
<tr><td colspan="6">Key Technical Indexes</td></tr>
<tr><td rowspan="6">Energy consumption</td><td colspan="3">Energy Consumption Targets</td><td>Design Value</td><td>Average value for typical</td></tr>
<tr><td colspan="3">Annual Heating Demand（kWh/m²a）</td><td>15.88</td><td></td></tr>
<tr><td colspan="3">Annual Cooling Demand（kWh/m²a）</td><td>6.24</td><td></td></tr>
<tr><td colspan="3">Primary Energy Consumption kWh/(m²)</td><td>92.98</td><td></td></tr>
<tr><td colspan="3">Source to Site Conversion Factor (Electricity)</td><td colspan="2"></td></tr>
<tr><td colspan="5">Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug</td></tr>
<tr><td colspan="6">Energy saving approaches（Yes for√）</td></tr>
<tr><td rowspan="4">Passive Approaches</td><td>Skylight</td><td>Solar Tubes</td><td>Thermal Zoning</td><td colspan="2">Passive Solar Heat Gain</td></tr>
<tr><td>√</td><td></td><td></td><td colspan="2">√</td></tr>
<tr><td>Site Vegetation</td><td>Natural Ventilation</td><td>Ground Cooling</td><td colspan="2">Sun shading</td></tr>
<tr><td></td><td>√</td><td>√</td><td colspan="2"></td></tr>
<tr><td rowspan="4">Active Approaches</td><td>Energy Efficient Lighting</td><td>Advanced Lighting Controls</td><td>Efficient Appliances</td><td>Load Management</td><td>Mechanical Air Heat Recovery</td></tr>
<tr><td>√</td><td></td><td>√</td><td></td><td>√</td></tr>
<tr><td>Displacement Ventilation</td><td>Radiant Heating</td><td>Radiant Cooling</td><td>Air Source Heat Pump</td><td>Hot Water Heat Recovery</td></tr>
<tr><td>√</td><td></td><td></td><td>√</td><td></td></tr>
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APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

<table>
<tr><td colspan="4">Basic Information</td></tr>
<tr><td>Building Name</td><td>Shenyang Jianzhu University Sino-German Passive House</td><td>Location (City)</td><td>Shenyang</td></tr>
<tr><td>Building Type</td><td colspan="3">☐Residential ☐ √ Office ☐School ☐Others (Please Specify)__________</td></tr>
<tr><td>Heating Degree Day</td><td></td><td>Cooling Degree Day</td><td></td></tr>
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<table>
<tr><td>Net Floor Area（m²）</td><td>1600</td><td>Treated floor area（m²）</td><td>1600</td></tr>
<tr><td>Number of storeys</td><td>2F/ 1 BF</td><td>Completion Date</td><td>2015.05</td></tr>
<tr><td>3Incremental Cost Allocation（%）</td><td colspan="3">☐Passive approaches（ 20 %） ☐Active approaches（ 15 %）
☐Renewable energy system（ 15 %） ☐Control system（ 25 %）</td></tr>
<tr><td>Source of Incremental Cost</td><td colspan="3">☐Government Subsidy（ 50 %） ☐Project Incentive（ 15 %）
☐ √ Self-fund（ 25 %） ☐Donation/Industry in-kind support（10 %）</td></tr>
<tr><td colspan="4">Key Technical Indexes</td></tr>
</table>

<table>
<tr><td rowspan="6">Energy consumption</td><td>Energy Consumption Targets</td><td>Design Value</td><td>Average value for typical</td></tr>
<tr><td>Annual Heating Demand（kWh/m²a）</td><td>17.55</td><td></td></tr>
<tr><td>Annual Cooling Demand（kWh/m²a）</td><td>10.85</td><td></td></tr>
<tr><td>Primary Energy Consumption kWh/(m²)</td><td>6.55</td><td></td></tr>
<tr><td>Source to Site Conversion Factor (Electricity)</td><td colspan="2"></td></tr>
<tr><td colspan="3">Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug</td></tr>
<tr><td colspan="4">Energy saving approaches（Yes for√）</td></tr>
</table>

<table>
<tr><td rowspan="4">Passive Approaches</td><td>Skylight</td><td>Solar Tubes</td><td>Thermal Zoning</td><td>Passive Solar Heat Gain</td></tr>
<tr><td>√</td><td>√</td><td>√</td><td>√</td></tr>
<tr><td>Site Vegetation</td><td>Natural Ventilation</td><td>Ground Cooling</td><td>Sun shading</td></tr>
<tr><td>√</td><td>√</td><td>√</td><td>√</td></tr>
</table>

<table>
<tr><td rowspan="4">Active Approaches</td><td>Energy Efficient Lighting</td><td>Advanced Lighting Controls</td><td>Efficient Appliances</td><td>Load Management</td><td>Mechanical Air Heat Recovery</td></tr>
<tr><td>√</td><td>√</td><td>√</td><td>√</td><td>√</td></tr>
<tr><td>Displacement Ventilation</td><td>Radiant Heating</td><td>Radiant Cooling</td><td>Air Source Heat Pump</td><td>Hot Water Heat Recovery</td></tr>
<tr><td>√</td><td>√</td><td></td><td>√</td><td></td></tr>
</table>

<table>
<tr><th colspan="6">Best Practices Information Collection Template</th></tr>
<tr><td colspan="6">Basic Information</td></tr>
<tr><td>Building Name</td><td>Municipal Party School</td><td colspan="2">Location (City)</td><td colspan="2">Weihai</td></tr>
<tr><td>Building Type</td><td colspan="5">☐Residential ☐ √ Office ☐School ☐Others (Please Specify)_________</td></tr>
<tr><td>Heating Degree Day</td><td></td><td colspan="2">Cooling Degree Day</td><td colspan="2"></td></tr>
<tr><td>Net Floor Area (m²)</td><td>15919</td><td colspan="2">Treated floor area (m²)</td><td colspan="2">14020</td></tr>
<tr><td>Number of storeys</td><td>5F/ 1 BF</td><td colspan="2">Completion Date</td><td colspan="2">2017.03</td></tr>
<tr><td>3Incremental Cost Allocation (%)</td><td colspan="5">☐Passive approaches (%) ☐Active approaches (%)
☐Renewable energy system (%) ☐Control system (%)</td></tr>
<tr><td>Source of Incremental Cost</td><td colspan="5">☐Government Subsidy (%) ☐Project Incentive (%)
☐ √ Self-fund (%) ☐Donation/Industry in-kind support (%)</td></tr>
<tr><td colspan="6">Key Technical Indexes</td></tr>
<tr><td rowspan="6">Energy consumption</td><td colspan="2">Energy Consumption Targets</td><td>Design Value</td><td colspan="2">Average value for typical</td></tr>
<tr><td colspan="2">Annual Heating Demand (kWh/m²a)</td><td>1.06</td><td colspan="2"></td></tr>
<tr><td colspan="2">Annual Cooling Demand (kWh/m²a)</td><td>4.97</td><td colspan="2"></td></tr>
<tr><td colspan="2">Primary Energy Consumption kWh/(m²)</td><td>102.79</td><td colspan="2"></td></tr>
<tr><td colspan="2">Source to Site Conversion Factor (Electricity)</td><td colspan="3"></td></tr>
<tr><td colspan="5">Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug</td></tr>
<tr><td colspan="6">Energy saving approaches (Yes for√)</td></tr>
<tr><td rowspan="4">Passive Approaches</td><td>Skylight</td><td>Solar Tubes</td><td>Thermal Zoning</td><td colspan="2">Passive Solar Heat Gain</td></tr>
<tr><td>√</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>Site Vegetation</td><td>Natural Ventilation</td><td>Ground Cooling</td><td colspan="2">Sun shading</td></tr>
<tr><td>√</td><td>√</td><td></td><td colspan="2">√</td></tr>
<tr><td>Active Approaches</td><td>Energy Efficient Lighting</td><td>Advanced Lighting Controls</td><td>Efficient Appliances</td><td>Load Management</td><td>Mechanical Air Heat Recovery</td></tr>
</table>

	√		√		√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	√	√			

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	The City College of Jilin Jianzhu University	Location (City)	Changchun
Building Type	☐Residential ☐ √ Office ☐School ☐Others (Please Specify)_________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area（m^2）	1187.8	Treated floor area（m^2）	667
Number of storeys	2F/ BF	Completion Date	2016.12
3Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ 41 %） ☐Project Incentive（ %） ☐Self-fund（ 48 %） ☐Donation/Industry in-kind support（ 11 %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）	**13.41**	
	Annual Cooling Demand（kWh/m^2a）	**14.10**	
	Primary Energy Consumption kWh/(m^2)	**47562**	
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches（Yes for√）					
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain	
	√		√		
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading	
		√			
Active Approaches	Energy Efficient	Advanced Lighting	Efficient Appliances	Load Management	Mechanical Air Heat Recovery

	Lighting	Controls			
	√		√		√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	√	√	√		

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	CABR Net Zero Energy Building	Location (City)	Beijing
Building Type	☐Residential ☐ √ Office ☐School ☐Others (Please Specify)________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area（m^2）	4025	Treated floor area（m^2）	
Number of storeys	4F/ 0 BF	Completion Date	2014.5
3Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐ √ Self-fund（ %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）		
	Annual Cooling Demand（kWh/m^2a）		
	Primary Energy Consumption kWh/(m^2)	**25**	
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches（Yes for√）					
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain	
	√	√	√	√	
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading	
		√		√	
Active Approaches	Energy Efficient	Advanced Lighting	Efficient Appliances	Load Management	Mechanical Air Heat Recovery

	Lighting	Controls			
	√	√	√	√	√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
		√	√		

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	TENIO Green Office	Location (City)	Tianjin
Building Type	☐Residential ☐ √ Office ☐School ☐Others (Please Specify)_________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area（m^2）	5756	Treated floor area（m^2）	5756
Number of storeys	F/ BF	Completion Date	2012.12
3Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐ √ Self-fund（ %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）	**58.32**	
	Annual Cooling Demand（kWh/m^2a）	**55.40**	
	Primary Energy Consumption $kWh/(m^2)$	**113.72**	
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches（Yes for√）				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√		√	
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	√	√		√

Active Approaches	Energy Efficient	Advanced Lighting	Efficient Appliances	Load Management	Mechanical Air Heat Recovery

	Lighting	Controls			
	√	√	√	√	√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
		√	√		

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Qingdao Eco Park	Location (City)	Qingdao
Building Type	☐Residential ☐ √ Office ☐School ☐Others (Please Specify)________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area（m^2）	13768.6	Treated floor area（m^2）	13768.6
Number of storeys	F/ BF	Completion Date	2016.07
3Incremental Cost Allocation（%）	☐Passive approaches（55 %） ☐Active approaches（ 8 %） ☐Renewable energy system（ 32 %） ☐Control system（ 5 %）		
Source of Incremental Cost	☐Government Subsidy（ 14 %） ☐Project Incentive（ %） ☐ √ Self-fund（ 86 %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）	**12**	**60**
	Annual Cooling Demand（kWh/m^2a）	**22**	**110**
	Primary Energy Consumption kWh/(m^2)	**60**	**260**
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches（Yes for√）				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√		√	√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	√	√		√

Active Approaches	Energy Efficient	Advanced Lighting	Efficient Appliances	Load Management	Mechanical Air Heat Recovery

	Lighting	Controls			
	√	√	√	√	√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
		√			

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Shandong Urban Construction Vocational College	Location (City)	Jinan
Building Type	☐Residential ☐ √ Office ☐School ☐Others (Please Specify)_________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area（m^2）	21428.67	Treated floor area（m^2）	20963.38
Number of storeys	6F/ 1 BF	Completion Date	2018.03
3Incremental Cost Allocation（%）	☐Passive approaches（ 35 %） ☐Active approaches（ 10 %） ☐Renewable energy system（ 43 %） ☐Control system（ 12 %）		
Source of Incremental Cost	☐Government Subsidy（ 100 %） ☐Project Incentive（ %） ☐Self-fund（ %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）	21.4	39.5
	Annual Cooling Demand（kWh/m^2a）	23.6	38.6
	Primary Energy Consumption $kWh/(m^2)$	35	81
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches（Yes for√）				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√	√	√	√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	√	√		√

	Energy	Advanced	Efficient	Load	Mechanical Air Heat

Active Approaches	Efficient Lighting	Lighting Controls	Appliances	Management	Recovery
	√	√	√	√	√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery

APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template

Basic Information			
Building Name	Velux Office Building	Location (City)	Langfang
Building Type	☐Residential ☐ √ Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area（m^2）	2014.5	Treated floor area（m^2）	
Number of storeys	3F/ 0BF	Completion Date	2013.05
3Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐ √ Self-fund（ %） ☐Donation/Industry in-kind support（ %）		
Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）		
	Annual Cooling Demand（kWh/m^2a）		
	Primary Energy Consumption kWh/(m^2)	**34**	**60**
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		
Energy saving approaches（Yes for√）			

	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain

Passive Approaches	√		√	√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
		√		√

Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√		√		
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
		√	√		

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Tibet Chengfa Energy saving building material Office	Location (City)	Tibet
Building Type	☐Residential ☐ √ Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area（m^2）	2612.33	Treated floor area（m^2）	2612.33
Number of storeys	3F/ BF	Completion Date	2016.12
3Incremental Cost Allocation（%）	☐Passive approaches（ 35 %） ☐Active approaches（ 25 %） ☐Renewable energy system（ 30 %） ☐Control system（ 10 %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐ √ Self-fund（ %） ☐Donation/Industry in-kind support（ %）		
Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）	**13.44**	**34.39**

	Annual Cooling Demand（kWh/m²a）		
	Primary Energy Consumption kWh/(m²)	**72**	
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches（Yes for√）

Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√			√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	√	√		√

Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√	√	√	√	√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
		√			

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information

Building Name	Zibo Linzi Health nursing home	Location (City)	Zibo
Building Type	☐ √Residential ☐Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area（m²）	4645	Treated floor area（m²）	4645
Number of storeys	6F/ 1BF	Completion Date	2018.03
3Incremental Cost Allocation（%）	☐Passive approaches（ 78.6 %） ☐Active approaches（ 21.4 %） ☐Renewable energy system（ 0 %） ☐Control system（ 0 %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %）		

	☐ √ Self-fund（100 %） ☐Donation/Industry in-kind support（ %）			
Key Technical Indexes				
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**	
	Annual Heating Demand（kWh/m²a）	5.07	12.68	
	Annual Cooling Demand（kWh/m²a）	8.99	22.47	
	Primary Energy Consumption kWh/(m²)	20.66	51.7	
	Source to Site Conversion Factor (Electricity)			
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug			
Energy saving approaches（Yes for√）				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√			√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	√	√		

Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√		√	√	√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Changpeng Car decoration manufacturing Office	Location (City)	Dingzhou
Building Type	☐Residential ☐ √ Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day		Cooling Degree Day	

<table>
<tr><td>Net Floor Area（m²）</td><td>2859</td><td>Treated floor area（m²）</td><td colspan="2">1657</td></tr>
<tr><td>Number of storeys</td><td>3F/ BF</td><td>Completion Date</td><td colspan="2">2016.11</td></tr>
<tr><td>3Incremental Cost Allocation（%）</td><td colspan="4">☐Passive approaches（ %） ☐Active approaches（ %）
☐Renewable energy system（ %） ☐Control system（ %）</td></tr>
<tr><td>Source of Incremental Cost</td><td colspan="4">☐Government Subsidy（ %） ☐Project Incentive（ %）
☐ √ Self-fund（ %） ☐Donation/Industry in-kind support（ %）</td></tr>
<tr><td colspan="5">Key Technical Indexes</td></tr>
<tr><td rowspan="7">Energy consumption</td><td colspan="2">Energy Consumption Targets</td><td>Design Value</td><td>Average value for typical</td></tr>
<tr><td colspan="2">Annual Heating Demand（kWh/m²a）</td><td>15</td><td></td></tr>
<tr><td colspan="2">Annual Cooling Demand（kWh/m²a）</td><td>24</td><td></td></tr>
<tr><td colspan="2">Primary Energy Consumption kWh/(m²)</td><td>120</td><td></td></tr>
<tr><td colspan="2">Source to Site Conversion Factor (Electricity)</td><td colspan="2"></td></tr>
<tr><td colspan="4">Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug</td></tr>
</table>

<table>
<tr><td colspan="6">Energy saving approaches（Yes for√）</td></tr>
<tr><td rowspan="4">Passive Approaches</td><td>Skylight</td><td>Solar Tubes</td><td>Thermal Zoning</td><td colspan="2">Passive Solar Heat Gain</td></tr>
<tr><td>√</td><td></td><td></td><td colspan="2">√</td></tr>
<tr><td>Site Vegetation</td><td>Natural Ventilation</td><td>Ground Cooling</td><td colspan="2">Sun shading</td></tr>
<tr><td></td><td>√</td><td></td><td colspan="2">√</td></tr>
<tr><td rowspan="4">Active Approaches</td><td>Energy Efficient Lighting</td><td>Advanced Lighting Controls</td><td>Efficient Appliances</td><td>Load Management</td><td>Mechanical Air Heat Recovery</td></tr>
<tr><td>√</td><td></td><td>√</td><td>√</td><td>√</td></tr>
<tr><td>Displacement Ventilation</td><td>Radiant Heating</td><td>Radiant Cooling</td><td>Air Source Heat Pump</td><td>Hot Water Heat Recovery</td></tr>
<tr><td></td><td>√</td><td>√</td><td></td><td></td></tr>
</table>

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information					
Building Name	Binhai New Area Community Cultural Activity Center	Location (City)	Tianjin		
Building Type	☐Residential ☐Office ☐School ☐Others (Please Specify)_ _Activity Center_				
Heating Degree Day		Cooling Degree Day			
Net Floor Area（m^2）	9864.89	Treated floor area（m^2）	6977.73		
Number of storeys	4F/ 1 BF	Completion Date	2015		
3Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）				
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐ √ Self-fund（ %） ☐Donation/Industry in-kind support（ %）				
Key Technical Indexes					
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**		
	Annual Heating Demand（kWh/m^2a）	**11.53**			
	Annual Cooling Demand（kWh/m^2a）	**8.95**			
	Primary Energy Consumption kWh/(m^2)				
	Source to Site Conversion Factor (Electricity)				
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug				
Energy saving approaches（Yes for√）					
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain	
	√				
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading	
	√	√		√	
	Energy	Advanced	Efficient	Load	Mechanical Air Heat

Active Approaches	Efficient Lighting	Lighting Controls	Appliances	Management	Recovery
	√	√	√	√	√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
		√	√		

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information

Building Name	Tianjin Eco-City Public House Phase II	Location (City)	Tianjin
Building Type	☐ √ Residential ☐Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area（m^2）	5802	Treated floor area（m^2）	4672
Number of storeys	F/ BF	Completion Date	2018.01
3Incremental Cost Allocation（%）	☐Passive approaches（ 30 %） ☐Active approaches（ 60 %） ☐Renewable energy system（ 10 %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐ √ Self-fund（ 100 %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes

Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）	**13.21**	**33.02**
	Annual Cooling Demand（kWh/m^2a）	**16.23**	**40.58**
	Primary Energy Consumption kWh/(m^2)	**48.24**	**100**
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches（Yes for√）

	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain

<table>
<tr><td rowspan="3">Passive
Approaches</td><td>√</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Site Vegetation</td><td colspan="2">Natural Ventilation</td><td colspan="2">Ground Cooling</td><td colspan="2">Sun shading</td></tr>
<tr><td></td><td colspan="2">√</td><td colspan="2"></td><td colspan="2">√</td></tr>
<tr><td rowspan="4">Active Approaches</td><td>Energy Efficient Lighting</td><td>Advanced Lighting Controls</td><td colspan="2">Efficient Appliances</td><td colspan="2">Load Management</td><td>Mechanical Air Heat Recovery</td></tr>
<tr><td>√</td><td></td><td colspan="2">√</td><td colspan="2"></td><td></td></tr>
<tr><td>Displacement Ventilation</td><td>Radiant Heating</td><td colspan="2">Radiant Cooling</td><td colspan="2">Air Source Heat Pump</td><td>Hot Water Heat Recovery</td></tr>
<tr><td></td><td></td><td colspan="2"></td><td colspan="2">√</td><td></td></tr>
</table>

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

<table>
<tr><td colspan="5">Basic Information</td></tr>
<tr><td>Building Name</td><td>Chengjian Huating Kingdergardon</td><td>Location (City)</td><td colspan="2">Weihai</td></tr>
<tr><td>Building Type</td><td colspan="4">☐Residential ☐Office ☐ √ School ☐Others (Please Specify)________</td></tr>
<tr><td>Heating Degree Day</td><td></td><td>Cooling Degree Day</td><td colspan="2"></td></tr>
<tr><td>Net Floor Area（m²）</td><td>5647.66</td><td>Treated floor area（m²）</td><td colspan="2">5174.06</td></tr>
<tr><td>Number of storeys</td><td>F/ BF</td><td>Completion Date</td><td colspan="2"></td></tr>
<tr><td>3Incremental Cost Allocation（%）</td><td colspan="4">☐Passive approaches（ 70 %） ☐Active approaches（ 25 %）
☐Renewable energy system（ 2 %） ☐Control system（ 3 %）</td></tr>
<tr><td>Source of Incremental Cost</td><td colspan="4">☐Government Subsidy（ 50 %） ☐Project Incentive（ %）
☐Self-fund（ 50 %） ☐Donation/Industry in-kind support（ %）</td></tr>
<tr><td colspan="5">Key Technical Indexes</td></tr>
<tr><td rowspan="6">Energy consumption</td><td colspan="2">Energy Consumption Targets</td><td>Design Value</td><td>Average value for typical</td></tr>
<tr><td colspan="2">Annual Heating Demand（kWh/m²a）</td><td>13.87</td><td></td></tr>
<tr><td colspan="2">Annual Cooling Demand（kWh/m²a）</td><td>9.06</td><td></td></tr>
<tr><td colspan="2">Primary Energy Consumption kWh/(m²)</td><td>114.56</td><td>120</td></tr>
<tr><td colspan="2">Source to Site Conversion Factor (Electricity)</td><td colspan="2"></td></tr>
<tr><td colspan="4">Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug</td></tr>
<tr><td colspan="5">Energy saving approaches（Yes for√）</td></tr>
<tr><td rowspan="4">Passive Approaches</td><td>Skylight</td><td>Solar Tubes</td><td>Thermal Zoning</td><td>Passive Solar Heat Gain</td></tr>
<tr><td>√</td><td></td><td></td><td>√</td></tr>
<tr><td>Site Vegetation</td><td>Natural Ventilation</td><td>Ground Cooling</td><td>Sun shading</td></tr>
<tr><td></td><td>√</td><td></td><td>√</td></tr>
<tr><td>Active Approaches</td><td>Energy Efficient</td><td>Advanced Lighting | Efficient Appliances</td><td>Load Management</td><td>Mechanical Air Heat Recovery</td></tr>
</table>

	Lighting	Controls			
	√		√		√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	√	√		√	

APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template

Basic Information					
Building Name	The Home of Future	Location (City)		Weifang	
Building Type	☐Residential ☐ √Office ☐School ☐Others (Please Specify)__________				
Heating Degree Day		Cooling Degree Day			
Net Floor Area (m^2)	2287	Treated floor area (m^2)		2023	
Number of storeys	3F/ 1 BF	Completion Date		2014.12	
3Incremental Cost Allocation (%)	☐Passive approaches (50 %) ☐Active approaches (10 %) ☐Renewable energy system (10 %) ☐Control system (30 %)				
Source of Incremental Cost	☐Government Subsidy (60 %) ☐Project Incentive (%) ☐Self-fund (40 %) ☐Donation/Industry in-kind support (%)				
Key Technical Indexes					
Energy consumption	**Energy Consumption Targets**		**Design Value**	**Average value for typical**	
	Annual Heating Demand (kWh/m^2a)		**3.72**	**⩽15**	
	Annual Cooling Demand (kWh/m^2a)		**13.31**	**⩽15**	
	Primary Energy Consumption $kWh/(m^2)$		**113.07**	**⩽120**	
	Source to Site Conversion Factor (Electricity)				
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug				
Energy saving approaches (Yes for√)					
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain	
	√			√	
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading	
		√			
Active Approaches	Energy Efficient	Advanced Lighting	Efficient Appliances	Load Management	Mechanical Air Heat Recovery

	Lighting	Controls			
	√	√	√	√	√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
				√	

APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template

Basic Information

Building Name	Zhongsen Honggu Yipin Kindergarden	Location (City)	Nanchang
Building Type	☐Residential ☐Office ☐ √ School ☐Others (Please Specify)_________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area（m^2）	3881.96	Treated floor area（m^2）	3525.62
Number of storeys	3F/ 1BF	Completion Date	2017.12
3Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐ √ Self-fund（ 100%） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes

	Energy Consumption Targets	Design Value	Average value for typical
Energy consumption	Annual Heating Demand（kWh/m^2a）	**1.44**	**13.73**
	Annual Cooling Demand（kWh/m^2a）	**22.29**	**46.42**
	Primary Energy Consumption kWh/(m^2)	**62.97**	**138.52**
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches（Yes for√）

Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√			√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	√	√		√

Active Approaches	Energy Efficient	Advanced Lighting	Efficient Appliances	Load Management	Mechanical Air Heat Recovery

	Lighting	Controls			
	√	√	√		√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
				√	

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Water Front Zero Energy Home	Location (City)	Qinhuagndao
Building Type	☐ √ Residential ☐Office ☐School ☐Others (Please Specify)_________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area (m^2)	6718.4	Treated floor area (m^2)	6718.4
Number of storeys	18F/ 1 BF	Completion Date	2014.06
3Incremental Cost Allocation (%)	☐Passive approaches (%) ☐Active approaches (%) ☐Renewable energy system (%) ☐Control system (%)		
Source of Incremental Cost	☐Government Subsidy (%) ☐Project Incentive (%) ☐ √ Self-fund (%) ☐Donation/Industry in-kind support (%)		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand (kWh/m^2a)	**7.66**	**⩽15**
	Annual Cooling Demand (kWh/m^2a)	**8.12**	**⩽15**
	Primary Energy Consumption kWh/(m²)	**108**	**120**
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches (Yes for√)				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√			√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	√	√		

Active Approaches	Energy Efficient	Advanced Lighting	Efficient Appliances	Load Management	Mechanical Air Heat Recovery

	Lighting	Controls			
	√	√	√		√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	√			√	

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information

Building Name	CCT TECH Net Zero Energy Building	Location (City)	Chengdu
Building Type	☐Residential ☐ √ Office ☐School ☐Others (Please Specify)_________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area (m^2)	4409.69	Treated floor area (m^2)	4145.4
Number of storeys	4F/ BF	Completion Date	2016.03
3Incremental Cost Allocation (%)	☐Passive approaches (%) ☐Active approaches (%) ☐Renewable energy system (%) ☐Control system (%)		
Source of Incremental Cost	☐Government Subsidy (%) ☐Project Incentive (%) ☐ √ Self-fund (100 %) ☐Donation/Industry in-kind support (%)		

Key Technical Indexes

	Energy Consumption Targets	Design Value	Average value for typical
Energy consumption	Annual Heating Demand (kWh/m^2a)	**3.03**	
	Annual Cooling Demand (kWh/m^2a)	**40.89**	
	Primary Energy Consumption $kWh/(m^2)$	**60**	
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches (Yes for√)

Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√	√		√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	√	√	√	√

Active Approaches	Energy Efficient	Advanced Lighting	Efficient Appliances	Load Management	Mechanical Air Heat Recovery

	Lighting	Controls			
	√	√	√	√	√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Shoukai BrownStone Net Zero Energy Building	Location (City)	Xiamen
Building Type	☐ √ Residential ☐Office ☐School ☐Others (Please Specify)_________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area（m^2）	1500	Treated floor area（m^2）	1500
Number of storeys	3F/ 1 BF	Completion Date	2016.2
3Incremental Cost Allocation（%）	☐Passive approaches（ 50 %） ☐Active approaches（ 30 %） ☐Renewable energy system（ 10 %） ☐Control system（ 10 %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐ √ Self-fund（100 %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）	1	5
	Annual Cooling Demand（kWh/m^2a）	34	34
	Primary Energy Consumption kWh/(m²)	47	60
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches（Yes for√）				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√			√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	√	√		√

Active Approaches	Energy Efficient	Advanced Lighting	Efficient Appliances	Load Management	Mechanical Air Heat Recovery

	Lighting	Controls			
	√		√	√	
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
				√	

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Sheng Rong Eco Kindergarden	Location (City)	Dongguan
Building Type	☐Residential ☐Office ☐ √ School ☐Others (Please Specify)_________		
Heating Degree Day		Cooling Degree Day	
Net Floor Area（m²）	3400	Treated floor area（m²）	0
Number of storeys	3F/ BF	Completion Date	2012.06
3Incremental Cost Allocation（%）	☐Passive approaches（ 0 %） ☐Active approaches（ 0 %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐Self-fund（ %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m²a）	**0**	
	Annual Cooling Demand（kWh/m²a）	**0**	
	Primary Energy Consumption kWh/(m²)	**5**	
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including: ☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches（Yes for√）					
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain	
	√				
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading	
	√	√		√	
Active Approaches	Energy Efficient	Advanced Lighting	Efficient Appliances	Load Management	Mechanical Air Heat Recovery

	Lighting	Controls			
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery

APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template

<table>
<tr><td colspan="4">Basic Information</td></tr>
<tr><td>Building Name</td><td>CIFAL Training Center</td><td>Location (City)</td><td>Zhenjiang</td></tr>
<tr><td>Building Type</td><td colspan="3">☐Residential ☐ √ Office ☐School ☐Others (Please Specify)________</td></tr>
<tr><td>Heating Degree Day</td><td></td><td>Cooling Degree Day</td><td></td></tr>
<tr><td>Net Floor Area（m²）</td><td>12786</td><td>Treated floor area（m²）</td><td>12786</td></tr>
<tr><td>Number of storeys</td><td>6F/ BF</td><td>Completion Date</td><td>2017.10</td></tr>
<tr><td>3Incremental Cost Allocation（%）</td><td colspan="3">☐Passive approaches（ 92 %） ☐Active approaches（ 8 %）
☐Renewable energy system（ %） ☐Control system（ %）</td></tr>
<tr><td>Source of Incremental Cost</td><td colspan="3">☐Government Subsidy（ 40 %） ☐Project Incentive（ %）
☐ √ Self-fund（ 60 %） ☐Donation/Industry in-kind support（ %）</td></tr>
</table>

<table>
<tr><td colspan="4">Key Technical Indexes</td></tr>
<tr><td rowspan="6">Energy consumption</td><td>Energy Consumption Targets</td><td>Design Value</td><td>Average value for typical</td></tr>
<tr><td>Annual Heating Demand（kWh/m²a）</td><td>5.6</td><td>16.0</td></tr>
<tr><td>Annual Cooling Demand（kWh/m²a）</td><td>55.7</td><td>87.0</td></tr>
<tr><td>Primary Energy Consumption kWh/(m²)</td><td>112</td><td>280</td></tr>
<tr><td>Source to Site Conversion Factor (Electricity)</td><td colspan="2"></td></tr>
<tr><td colspan="3">Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug</td></tr>
</table>

<table>
<tr><td colspan="6">Energy saving approaches（Yes for√）</td></tr>
<tr><td rowspan="4">Passive Approaches</td><td>Skylight</td><td>Solar Tubes</td><td colspan="2">Thermal Zoning</td><td>Passive Solar Heat Gain</td></tr>
<tr><td>√</td><td>√</td><td colspan="2"></td><td>√</td></tr>
<tr><td>Site Vegetation</td><td>Natural Ventilation</td><td colspan="2">Ground Cooling</td><td>Sun shading</td></tr>
<tr><td>√</td><td>√</td><td colspan="2"></td><td>√</td></tr>
<tr><td>Active Approaches</td><td>Energy Efficient</td><td>Advanced Lighting</td><td>Efficient Appliances</td><td>Load Management</td><td>Mechanical Air Heat Recovery</td></tr>
</table>

	Lighting	Controls			
	√	√	√	√	√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
					√

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information

Building Name	Kajima Technical Research Institute building	Location (City)	Tokyo
Building Type	☐Residential ☐Office ☐School ☑Others (Please Specify)_Institute_		
Heating Degree Day	1,499 (HDD18)	Cooling Degree Day	248 (CDD24)
Net Floor Area（m^2）	9,000	Treated floor area（m^2）	
Number of storeys	5F	Completion Date	2011,January
Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐Self-fund（ %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes

	Energy Consumption Targets	**Design Value**	**Average value for typical**
Energy consumption	Annual Heating Demand（kWh/m^2a）		
	Annual Cooling Demand（kWh/m^2a）		
	Primary Energy Consumption kWh/(m²)	254	
	Source to Site Conversion Factor (Electric		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☑Plug		

Energy saving approaches（Yes for√）

Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain	
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading	
				√	
Active Approaches	Energy Efficient	Advanced Lighting	Efficient Appliances	Load Management	Mechanical Air Heat Recovery

	Lighting	Controls			
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
		√	√		
	Other	Task Ambient H/C Visualization			

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information

Building Name	Taisei Sapporo Building	Location (City)	Sapporo
Building Type	☐Residential ☑Office ☐School ☐Others (Please Specify)_________		
Heating Degree Day	3,587 (HDD18)	Cooling Degree Day	2 (CDD24)
Net Floor Area (m^2)	7,000	Treated floor area (m^2)	
Number of stories	8F	Completion Date	2006,June
Incremental Cost Allocation (%)	☐Passive approaches (- %) ☐Active approaches (- %) ☐Renewable energy system (- %) ☐Control system (- %)		
Source of Incremental Cost	☐Government Subsidy (- %) ☐Project Incentive (- %) ☐Self-fund (- %) ☐Donation/Industry in-kind support (- %)		

Key Technical Indexes

Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand (kWh/m^2a)	-	-
	Annual Cooling Demand (kWh/m^2a)	-	-
	Primary Energy Consumption kWh/(m²)	224	505
	Source to Site Conversion Factor (Electric	2.71(kWh_{prim} / kWh)	
	Primary Energy Consumption Including:☑Heating/Cooling☑Lighting ☑Plug		
Building energy codes or standards	Act on the Rational Use of Energy / JAPAN		

Energy saving approaches (Yes for√)

Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√		-	-
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	-	√	-	-
	Others	Outer insulation, Day-lighting system (T-soleil), Eco boid, Minimize window size & Low-e glass		

Active Approaches	Energy	Advanced	Efficient	Load	Mechanical Air Heat

	Efficient Lighting	Lighting Controls	Appliances	Management	Recovery
	√	-	√	-	-
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	-	√	√	√	-
	Other	Thermal active building system Free cooling			

APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template					
Basic Information					
Building Name	21 Komaba Center forEducational Excellence building	Location (City)	Tokyo		
Building Type	☐Residential ☐Office ☐School ☑Others (Please Specify) Multi-purpose				
Heating Degree Day	1,499 (HDD18)	Cooling Degree Day	248 (CDD24)		
Net Floor Area (m^2	4,477	Treated floor area (m^2)	4,477		
Number of storeys	5	Completion Date	May, 2011		
Incremental Cost Allocation (%)	☐Passive approaches (%) ☐Active approaches (%) ☐Renewable energy system (%) ☐Control system (%)				
Source of Incremental Cost	☐Government Subsidy (67 %) ☐Project Incentive (%) ☐Self-fund (33%) ☐Donation/Industry in-kind support (%)				
Key Technical Indexes					
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**		
	Annual Heating Demand (kWh/m^2a)				
	Annual Cooling Demand (kWh/m^2a)				
	Primary Energy Consumption kWh/(m²)	170			
	ource to Site Conversion Factor (Electricity)				
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☑Plug				
Energy saving approaches (Yes for√)					
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain	
	√			√	
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading	
		√		√	
	Others	Smart double-skin cladding			
	Energy	Advanced	Efficient	Load	Mechanical Air Heat

Active Approaches	Efficient Lighting	Lighting Controls	Appliances	Management	Recovery
	√	√			√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
		√	√		
	Other	integrated system GSHP Desiccant driven by exhaust heat from HP			

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Taisei's ZEB	Location (City)	Yokohama
Building Type	☐Residential ☑Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day	1564(HDD18)	Cooling Degree Day	191(CDD24)
Net Floor Area (m^2)	1,277	Treated floor area (m^2)	
Number of stories	3F	Completion Date	2014,May
Incremental Cost Allocation (%)	☐Passive approaches (- %) ☐Active approaches (- %) ☐Renewable energy system (- %) ☐Control system (- %)		
Source of Incremental Cost	☐Government Subsidy (- %) ☐Project Incentive (- %) ☐Self-fund (- %) ☐Donation/Industry in-kind support (- %)		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand (kWh/m^2a)	25	-
	Annual Cooling Demand (kWh/m^2a)	23	-
	Primary Energy Consumption $kWh/(m^2)$	-8.3	505
	Source to Site Conversion Factor (Electricity)	Electricity:2.71(kWh_{prim} / kWh) Fuel:12.5(kWh_{prim} / Nm^3)	
	Primary Energy Consumption Including:☑Heating/Cooling ☑Lighting☑Plug		
Building energy codes or standards	Act on the Rational Use of Energy / JAPAN		

Energy saving approaches (Yes for√)

<table>
<tr><td rowspan="5">Passive Approaches</td><td>Skylight</td><td colspan="2">Solar Tubes</td><td>Thermal Zoning</td><td>Passive Solar Heat Gain</td></tr>
<tr><td>√</td><td colspan="2">-</td><td>√</td><td>√</td></tr>
<tr><td>Site Vegetation</td><td colspan="2">Natural Ventilation</td><td>Ground Cooling</td><td>Sun shading</td></tr>
<tr><td>√</td><td colspan="2">√</td><td>√</td><td>√</td></tr>
<tr><td>Others (Please Specify)</td><td colspan="4">Balcony, Low-e glass, Day-lighting system (T-Light Cube), Rainwater utilization</td></tr>
<tr><td rowspan="5">Active Approaches</td><td>Energy Efficient Lighting</td><td>Advanced Lighting Controls</td><td>Efficient Appliances</td><td>Load Management</td><td>Mechanical Air Heat Recovery</td></tr>
<tr><td>√</td><td>√</td><td>√</td><td>-</td><td>-</td></tr>
<tr><td>Displacement Ventilation</td><td>Radiant Heating</td><td>Radiant Cooling</td><td>Air Source Heat Pump</td><td>Hot Water Heat Recovery</td></tr>
<tr><td>-</td><td>√</td><td>√</td><td>√</td><td>-</td></tr>
<tr><td>Other (Please Specify)</td><td colspan="4">Task-ambient control by human detection sensor (T-Zone Saver), Thermal active building system, Personal air diffuser, Smart-BEMS, Fuel Cell, BIPV</td></tr>
</table>

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Hokusetsu Office of The Kansai Electric Power Co., Inc	Location (City)	Osaka
Building Type	☐Residential ☐Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day	1,472 (HDD18)	Cooling Degree Day	337 (CDD24)
Net Floor Area（m^2	1,603	Treated floor area（m^2）	8,453
Number of storeys	6F	Completion Date	2012, August
Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐Self-fund（ %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）	**0.4**	
	Annual Cooling Demand（kWh/m^2a）	**32.6**	
	Primary Energy Consumption kWh/(m^2)	**146.0**	
	ource to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches（Yes for√）				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
			√	
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	√		√	√

	Energy	Advanced	Efficient	Load	Mechanical Air Heat

Active Approaches	Efficient Lighting	Lighting Controls	Appliances	Management	Recovery
	√	√	√	√	√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
				√	

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Akasaka K Tower building	Location (City)	Tokyo
Building Type	☐Residential ☑Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day	1,499 (HDD18)	Cooling Degree Day	248 (CDD24)
Net Floor Area（m^2	53,777	Treated floor area（m^2）	
Number of storeys	30F	Completion Date	2012, January
Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐Self-fund（ %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m²a）		
	Annual Cooling Demand（kWh/m²a）		
	Primary Energy Consumption kWh/(m²)	338	
	Source to Site Conversion Factor (Electricity		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		

Energy saving approaches（Yes for√）				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	Site	Natural	Ground Cooling	Sun shading

	Vegetation	Ventilation			
					√
	Others	Low-e glass			
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	Other (Please Specify)	Energy fault detection system Heat source optimum integrated control system Direct linkage control of multi-and the central heat source Latent heat sensible heat separation air conditioning Water heat storage layer control system, Visualization			

APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template

Basic Information			
Building Name	Zero Carbon Green Home	Location (City)	Goyang-si
Building Type	■Residential ☐Office ☐School ☐Others (Please Specify)_________		
Heating Degree Day	3000.3	Cooling Degree Day	137.1
Net Floor Area (m^2	1,273.15	Treated floor area (m^2)	2,235.09
Number of storeys	8F/ BF	Completion Date	2012.11.01
Incremental Cost Allocation (%)	☐ Passive approaches (70%) ☐ Active approaches (5 %) ☐ Renewable energy system (19 %) ☐ Control system (6 %)		
Source of Incremental Cost	☐Government Subsidy (77 %) ☐Project Incentive (%) ☐Self-fund (22 %) ☐Donation/Industry in-kind support (1 %)		
Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand (kWh/m^2a)	**26.5**	**170**
	Annual Cooling Demand (kWh/m^2a)	-	**45**

	Primary Energy Consumption kWh/(m²)	**120**	**400**
	Source to Site Conversion Factor (Electrici	**2.5**	
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		
Building energy codes or standards	**Building Energy Saving Criteria 2009**		

Energy saving approaches (Yes for √)

Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	-	**-**	**O**	**O**
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	-	**O**	**-**	**O**

Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	O	**O**	**O**	**-**	**O**
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	-	**O**	**-**	**-**	**-**

Active Approaches	Other	**Stack heat recovery system**

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information

Building Name	Seoul Energy Dream Center	Location (City)	Seoul
Building Type	☐Residential ■Office ☐School ■Others (Please Specify)_exhibition		
Heating Degree Day	3000	Cooling Degree Day	137
Net Floor Area（m^2	3762.32	Treated floor area（m^2）	3762.32
Number of storeys	3F/ 1BF	Completion Date	2012
Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐Self-fund（100 %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes

Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）	**26.0**	**70**
	Annual Cooling Demand（kWh/m^2a）	**30.5**	**90**
	Primary Energy Consumption $kWh/(m^2)$	**109.7**	**420**
	ource to Site Conversion Factor (Electricity)	**2.5**	
	Primary Energy Consumption Including:■Heating/Cooling ■Lighting ■Plug		
Building energy codes or standards	**Building Energy Saving Criteria 2009**		

Energy saving approaches（Yes for√）

Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
			√	√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
			√	√
	Others	Exterior Super Insulation, Triple Loe-w Glazing, Daylight		

		control, Movable Exterior Blinds,				
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery	
	√	√	√	√	√	
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery	
	√	√	√			

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	All Electric House	Location (City)	Daejeon, Korea
Building Type	■Residential ☐Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day	2768.3	Cooling Degree Day	106.7
Net Floor Area（m^2	156.7 m^2	Treated floor area（m^2）	214 m^2
Number of storeys	2F/ 0BF	Completion Date	2010
Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐Self-fund（100 %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical similar building**
	Annual Heating Demand（kWh/m^2a）	**42.2**	**135.0**
	Annual Cooling Demand（kWh/m^2a）	**4.2**	**7.0**
	Primary Energy Consumption kWh/(m^2)	**305.2**	**573.5**
	Source to Site Conversion Factor (Electricity)	**2.5**	
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐Plug		
Building energy codes or standards	**Korea Building Design Standard (2010)**		

Energy saving approaches（Yes for√）				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
			√	√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
		√		√
	Others (Please	High performance Window (42mm Low-e triple panes glazing)		

	Specify)	Exterior Blind, Exterior Insulation			
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√		√	√	√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
		√			
	Other	**GSHP System for Heating, Cooling, and DHW**			

APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template

Basic Information			
Building Name	NIER	Location (City)	Inchon
Building Type	☐Residential ■Office ☐School ■Others (Please Specify) exhibition		
Heating Degree Day	2688	Cooling Degree Day	100
Net Floor Area (m^2	1927.68	Treated floor area (m^2)	2449.24
Number of storeys	2F/1B	Completion Date	2011.4
Incremental Cost Allocation (%)	■Passive approaches (%) ■Active approaches (%) ■Renewable energy system (%) □Control system (%)		
Source of Incremental Cost	□Government Subsidy (%) □Project Incentive (%) ■Self-fund (100 %) □Donation/Industry in-kind support (%)		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand (kWh/m^2a)		**70**
	Annual Cooling Demand (kWh/m^2a)		**90**
	Primary Energy Consumption kWh/(m²)		**420**
	Source to Site Conversion Factor (Electricity)	**2.5**	
	Primary Energy Consumption Including: ■Heating/Cooling ■Lighting ■Plug		

Building energy codes or standards	**Building Energy Saving Criteria 2009**				
Energy saving approaches（Yes for√）					
Passive Approaches	Skylight	Solar Tubes		Thermal Zoning	Passive Solar Heat Gain
	√	√		√	√
	Site Vegetation	Natural Ventilation		Ground Cooling	Sun shading
		√		√	√
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√	√	√	√	
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	Other (Please Specify)	Task & ambient lighting			

APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template

Basic Information			
Building Name	Geoje Ok-sanli Residential building	Location (City)	Geoje
Building Type	■Residential ☐Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day	1908.1	Cooling Degree Day	107.6
Net Floor Area（m^2	93.39	Treated floor area（m^2）	377
Number of storeis	2F	Completion Date	2015.1.21
Incremental Cost Allocation（%）	☐Passive approaches（ 50%） ☐Active approaches（ 15%） ☐Renewable energy system（ 30%） ☐Control system（ 5%）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐Self-fund（100%） ☐Donation/Industry in-kind support（ %）		
Key Technical Indexes			
Energy	**Energy Consumption Targets**	**Design Value**	**Average value for**

consumption			typical
	Annual Heating Demand（kWh/m²a）	**24**	-
	Annual Cooling Demand（kWh/m²a）	**32**	-
	Primary Energy Consumption kWh/(m²)	**176**	-
	Source to Site Conversion Factor (Electricity)		
	Primary Energy Consumption Including: ■Heating/Cooling ☐Lighting ☐ Plug		
Building energy codes or standards	**Building Energy Saving Criteria 2012**		

Energy saving approaches（Yes for√）

Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√		√	√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
		√	√	√

Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√		√		√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	√			√	

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information

Building Name	Jinchun Zero-Energy Town House (100 Houses)	Location (City)	Jinchun
Building Type	☑Residential ☐Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day	2768.3	Cooling Degree Day	106.7
Net Floor Area（m²	145.75 x 100 units	Treated floor area（m²）	153.25 x 100 Units
Number of storeys	2F/ BF	Completion Date	Under Construction

Incremental Cost Allocation（%）	☐Passive approaches（ 60%） ☐Active approaches（ 10 %） ☐Renewable energy system（ 30 %） ☐Control system（ %）				
Source of Incremental Cost	☐Government Subsidy（ 15 %） ☐Project Incentive（ %） ☐Self-fund（ 85 %） ☐Donation/Industry in-kind support（ %）				
Key Technical Indexes					
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical similar building**		
	Annual Heating Demand（kWh/m²a）	**26**	**170**		
	Annual Cooling Demand（kWh/m²a）	**12**	**45**		
	Primary Energy Consumption kWh/(m²)	**78**	**400**		
	Source to Site Conversion Factor (Electricity)	**2.5**			
	Primary Energy Consumption Including: ☐✔Heating/Cooling ☐✔Lighting ☐Plug				
Building energy codes or standards	**ISO-13790 / PHPP 2007**				
Energy saving approaches（Yes for√）					
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain	
	✔		✔	✔	
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading	
		✔		✔	
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	✔		✔		√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	✔	✔		✔	

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Odae Mt. Korea National Park kyebangsan Branch Office	Location (City)	Pyeongchang

Building Type	☐Residential ■Office ☐School ☐Others (Please Specify)_________		
Heating Degree Day	4016.4	Cooling Degree Day	1
Net Floor Area（m^2	105.03	Treated floor area（m^2）	654.2
Number of stories	2F	Completion Date	2013.12.6
Incremental Cost Allocation（%）	☐Passive approaches（ 50%） ☐Active approaches（ 15%） ☐Renewable energy system（ 30%） ☐Control system（ 5%）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐Self-fund（ 100%） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes

Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical similar building**
	Annual Heating Demand（kWh/m^2a）	**38.6**	-
	Annual Cooling Demand（kWh/m^2a）	**3.6**	-
	Primary Energy Consumption kWh/(m^2)	-	-
	Source to Site Conversion Factor (Electricity)	**2.5**	
	Primary Energy Consumption Including:■Heating/Cooling ■Lighting ☐Plug		
Building energy codes or standards	**Building Energy Saving Criteria 2012**		

Energy saving approaches（Yes for√）

Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√		√	√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
		√	√	√

Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√		√		√

	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	√			√	

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information

Building Name	PHIKO No. 2	Location (City)	Namwon
Building Type	☑Residential ☐Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day	2300	Cooling Degree Day	100
Net Floor Area（m^2）	99.16	Treated floor area（m^2）	99.16
Number of storeys	1F/ BF	Completion Date	2015.12
Incremental Cost Allocation（%）	☐Passive approaches（ 52 %） ☐Active approaches（ 15 %） ☐Renewable energy system（ 33 %） ☐Control system（ - %）		
Source of Incremental Cost	☐Government Subsidy（ 20 %） ☐Project Incentive（ %） ☐Self-fund（ 80 %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes

	Energy Consumption Targets	Design Value	Average value for typical
Energy consumption	Annual Heating Demand（kWh/m^2a）	**44**	**170**
	Annual Cooling Demand（kWh/m^2a）	**13**	**45**
	Primary Energy Consumption $kWh/(m^2)$	**178**	**400**
	Source to Site Conversion Factor (Electricity)	**2.5**	
	Primary Energy Consumption Including: ☑Heating/Cooling ☑Lighting ☐Plug		
Building energy codes or standards	**ISO-13790 / PHPP 8.5**		

Energy saving approaches（Yes for√）

Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	✔		✔	✔
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading

Active Approaches		✔			✔
	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	✔				
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	✔	✔			
	Other	**Heat Exchange Ventilate System**			

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	On-Yang 6 dong Community Service Center	Location (City)	Asan
Building Type	☐Residential ■Office ☐School ☐Others (Please Specify)_________		
Heating Degree Day	2768.3	Cooling Degree Day	106.7
Net Floor Area（m^2）	1464.5	Treated floor area（m^2	7021
Number of storeis	2F/ 1BF	Completion Date	2014.6.10
Incremental Cost Allocation（%）	☐Passive approaches（ 50 %） ☐Active approaches（ 15 %） ☐Renewable energy system（ 30 %） ☐Control system（ 5 %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐Self-fund（100 %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）	**22**	**70-**
	Annual Cooling Demand（kWh/m^2a）	**16**	**-**
	Primary Energy Consumption $kWh/(m^2)$	**114**	**577.8**
	Source to Site Conversion Factor (Electricity)	**2.5**	
	Primary Energy Consumption Including:■Heating/Cooling ■Lighting ☐Plug		
Building energy codes or standards	**Building Energy Saving Criteria 2012**		

Energy saving approaches（Yes for√）

Passive Approaches				
	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√		√	√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
		√	√	√

Active Approaches					
	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√		√		√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	√			√	

APEC Nearly (Net) Zero Energy Building

Best Practices Information Collection Template

Basic Information

Building Name	SeongnamSampyeongdong PostOffice	Location (City)	Seongnam, S.Korea
Building Type	☐Residential ■Office ☐School ☐Others (Please Specify)_________		
Heating Degree Day	2688	Cooling Degree Day	100
Net Floor Area (m^2)	420.40	Treated floor area (m^2)	755.5
Number of storeys	3F	Completion Date	2010. 12. 18
Incremental Cost Allocation (%)	■Passive approaches (42 %) ☐Active approaches (%) ■Renewable energy system (58 %) ☐Control system (%)		
Source of Incremental Cost	■Government Subsidy (100%) ☐Project Incentive (%) ☐Self-fund (%) ☐Donation/Industry in-kind support (%)		

Key Technical Indexes

Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical similar building**
	Annual Heating Demand (kWh/m²a)	**11.2**	**70**
	Annual Cooling Demand (kWh/m²a)	**27.3**	**90**
	Primary Energy Consumption kWh/(m²)	**-22.3**	**420**
	Source to Site Conversion Factor (Electricity)	**2.5**	
	Primary Energy Consumption Including: ■Heating/Cooling ■Lighting ☐ Plug		
Building energy codes or standards	**Building Energy Saving Criteria 2009-**		

Energy saving approaches (Yes for√)

Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√	√	√	√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading

		√			√
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√	√	√	√	√
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	√				

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Bullitt Center	Location (City)	Seattle
Building Type	☐Residential ☐ √ Office ☐School ☐Others (Please Specify)__________		
Heating Degree Day	4,036	Cooling Degree Day	474
Net Floor Area（m^2）	4,800	Treated floor area（m^2）	3600
Number of storeys	6F/ BF	Completion Date	2012
3Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐ √ Self-fund（ %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）	**1.67**	**75.71**
	Annual Cooling Demand（kWh/m^2a）	**1.56**	
	Primary Energy Consumption kWh/(m^2)	**169.84**	**764.29**
	Source to Site Conversion Factor (Electricity)	**0.297**	
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		
Building energy	**Seattle, heating, cooling, lighting, plug and misc**		

codes or standards					
Energy saving approaches (Yes for√)					
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain	
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading	
	√	√		√	
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√	√	√	√	
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	√	√	√		√
	Other	**Groud source heat pump**			

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information

Building Name	Chrisney Library	Location (City)	Chrisney
Building Type	☐Residential ☐Office ☐School ☐ √ Others (Please Specify) Library		
Heating Degree Day	5179	Cooling Degree Day	1458
Net Floor Area (m^2)	223	Treated floor area (m^2)	221
Number of storeys	1F/ BF	Completion Date	April 2009
3Incremental Cost Allocation (%)	☐Passive approaches (%) ☐Active approaches (%) ☐Renewable energy system (%) ☐Control system (%)		
Source of Incremental Cost	☐ √ Government Subsidy (%) ☐Project Incentive (%) ☐Self-fund (%) ☐ √ Donation/Industry in-kind support (%)		

Key Technical Indexes

Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand (kWh/m^2a)		
	Annual Cooling Demand (kWh/m^2a)		
	Primary Energy Consumption kWh/(m²)	**177.27**	**2610.75**
	Source to Site Conversion Factor (Electricity)	**0.297**	
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		
Building energy codes or standards	**Hawaii, lighting, plug**		

Energy saving approaches (Yes for√)

Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√	√		√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
		√	√	√

Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√	√			
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
				√	
	Others	ground source heat pump			

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Environmental Tech. Center Sonoma State	Location (City)	Rohnert Park
Building Type	☐Residential ☐Office ☐School ☐ √ Others (Please Specify) Laboratory		
Heating Degree Day	2802	Cooling Degree Day	602
Net Floor Area（m^2）	204	Treated floor area（m^2）	204
Number of storeys	1F/ BF	Completion Date	July 2001
3Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐ √ Government Subsidy（100 %） ☐Project Incentive（ %） ☐Self-fund（ %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）		
	Annual Cooling Demand（kWh/m^2a）		
	Primary Energy Consumption $kWh/(m^2)$	**24.63**	**123.14**
	Source to Site Conversion Factor (Electricity)	**0.297**	
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		
Building energy	**California, heating, cooling, lighting, plug**		

codes or standards					
Energy saving approaches（Yes for√）					
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain	
	√			√	
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading	
		√		√	
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√	√			
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
		√			

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Hawaii Gateway Energy Center	Location (City)	Kailua-Kona
Building Type	☐Residential ☐Office ☐School ☐ √ Others (Please Specify)____ Assembly, Commercial office, Interpretive Center___		
Heating Degree Day	18	Cooling Degree Day	2033
Net Floor Area (m^2)	334	Treated floor area (m^2)	334
Number of storeys	1F/ BF	Completion Date	Jan 2005
3Incremental Cost Allocation (%)	☐Passive approaches (%) ☐Active approaches (%) ☐Renewable energy system (%) ☐Control system (%)		
Source of Incremental Cost	☐ √ Government Subsidy (100 %) ☐Project Incentive (%) ☐Self-fund (%) ☐Donation/Industry in-kind support (%)		

Key Technical Indexes		
Energy consumption	**Energy Consumption Targets**	**Design Value**
	Annual Heating Demand (kWh/m^2a)	
	Annual Cooling Demand (kWh/m^2a)	
	Primary Energy Consumption kWh/(m^2)	**294.04**
	Source to Site Conversion Factor (Electricity)	**0.297**
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug	
Building energy codes or standards	**Hawaii, lighting, plug**	

Energy saving approaches (Yes for√)				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
		√	√	√

Active Approaches	Energy	Advanced	Efficient	Load	Mechanical Air Heat

	Efficient Lighting	Lighting Controls	Appliances	Management	Recovery
	√	√			
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
			√		
	Other (Please Specify)	**Thermal Chimney**			

APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template

Basic Information			
Building Name	Leslie Shao-Ming Sun Field Station	Location (City)	San Mateo County
Building Type	☐Residential ☐Office ☐ √ School ☐Others (Please Specify)_____		
Heating Degree Day	948	Cooling Degree Day	1172
Net Floor Area（m^2）	1230	Treated floor area（m^2）	910
Number of storeys	1 F/ BF	Completion Date	June 2002
3Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐ √ Self-fund（ %） ☐ √ Donation/Industry in-kind support（ %）		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）		
	Annual Cooling Demand（kWh/m^2a）		
	Primary Energy Consumption $kWh/(m^2)$	**101.38**	
	Source to Site Conversion Factor (Electricity)	**0.297**	
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug		
Building energy	**California, heating, cooling, lighting, plug**		

codes or standards	

Energy saving approaches（Yes for√）

Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√			
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
		√		√

Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√	√			
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information

Building Name	Oberlin College Lewis Center	Location (City)	Oberlin
Building Type	☐Residential ☐Office ☐ √ School ☐Others (Please Specify)______		
Heating Degree Day	6500	Cooling Degree Day	500
Net Floor Area（m^2）	1263	Treated floor area（m^2）	
Number of storeys	2F/ BF	Completion Date	Jan 2000
Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐ √ Self-fund（ %） ☐Donation/Industry in-kind support（ %）		

Key Technical Indexes

Energy	**Energy Consumption Targets**	**Design Value**	**Average value for typical**

consumption	Annual Heating Demand（kWh/m²a）		**42.59**		**61.83**
	Annual Cooling Demand（kWh/m²a）		**7.26**		**32.49**
	Primary Energy Consumption kWh/(m²)		**349.66**		**543.22**
	Source to Site Conversion Factor (Electricity)		**0.297**		
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug				
Building energy codes or standards	**Ohio, lighting, plug**				
Energy saving approaches（Yes for√）					
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning		Passive Solar Heat Gain
	√				√
	Site Vegetation	Natural Ventilation	Ground Cooling		Sun shading
	√	√			√
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√	√			
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
		√	√		
	Others	Geothermal heat pumps			

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Omega Center for Sustainable Living	Location (City)	Rhinebeck
Building Type	☐Residential ☐Office ☐School ☐ √ Others Interpretive Center, Laboratory		
Heating Degree Day	6008	Cooling Degree Day	1176
Net Floor Area (m^2	576	Treated floor area (m^2)	576
Number of storeys	1F/ BF	Completion Date	May 2009
3Incremental Cost Allocation (%)	☐Passive approaches (%) ☐Active approaches (%) ☐Renewable energy system (%) ☐Control system (%)		
Source of Incremental Cost	☐Government Subsidy (%) ☐Project Incentive (%) ☐ √ Self-fund (40 %) ☐ √ Donation/Industry in-kind support (60 %)		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand (kWh/m^2a)	**9.72**	
	Annual Cooling Demand (kWh/m^2a)	**10.63**	
	Primary Energy Consumption $kWh/(m^2)$	**213.89**	**343.41**
	ource to Site Conversion Factor (Electricity)	**0.299**	
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐Plug		
Building energy codes or standards	**New York, heating, cooling, lighting, plug and misc**		

Energy saving approaches (Yes for√)				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√			√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
	√	√		√
	Energy	Advanced	Efficient	Load	Mechanical Air Heat

Active Approaches	Efficient Lighting	Lighting Controls	Appliances	Management	Recovery
	√	√			
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
		√	√		
	Other	**Groud source heat pump,** Geothermal heat pumps			

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	The Putney School Net Zero Energy Field House	Location (City)	Putney
Building Type	☐Residential ☐Office ☐ √ School ☐Others (Please Specify)_____		
Heating Degree Day	5698	Cooling Degree Day	1106
Net Floor Area（m^2	1560	Treated floor area（m^2）	1560
Number of storeys	1F/ BF	Completion Date	October 2009
3Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐Government Subsidy（ %） ☐Project Incentive（ %） ☐Self-fund（ %） ☐ √ Donation/Industry in-kind support（ %）		
Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand（kWh/m^2a）	**15.16**	**75.8**
	Annual Cooling Demand（kWh/m^2a）		
	Primary Energy Consumption kWh/(m^2)	**102.43**	**602.15**
	Source to Site Conversion Factor (Electricity)	**0.297**	
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐Plug		
Building energy	**Vermont, heating, lighting, plug**		

codes or standards					
Energy saving approaches（Yes for√）					
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain	
	√			√	
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading	
	√	√		√	
Active Approaches	Energy Efficient Lighting	Advanced Lighting Controls	Efficient Appliances	Load Management	Mechanical Air Heat Recovery
	√	√			
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
				√	

APEC Nearly (Net) Zero Energy Building Best Practices Information Collection Template

Basic Information			
Building Name	Science House at the Science Museum of Minnesota	Location (City)	St. Paul
Building Type	☐Residential ☐Office ☐School ☐ √ Others _Interpretive Center_		
Heating Degree Day	5601	Cooling Degree Day	1289
Net Floor Area（m^2	142	Treated floor area（m^2）	137
Number of storeys	1F/ BF	Completion Date	June 2003
3Incremental Cost Allocation（%）	☐Passive approaches（ %） ☐Active approaches（ %） ☐Renewable energy system（ %） ☐Control system（ %）		
Source of Incremental Cost	☐ √ Government Subsidy（ %） ☐Project Incentive（ %） ☐Self-fund（ %） ☐ √ Donation/Industry in-kind support（ %）		
Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**

<table>
<tr><td rowspan="5"></td><td colspan="3">Annual Heating Demand（kWh/m²a）</td><td colspan="2">23.77</td><td>59.43</td></tr>
<tr><td colspan="3">Annual Cooling Demand（kWh/m²a）</td><td colspan="2">2.05</td><td>5.13</td></tr>
<tr><td colspan="3">Primary Energy Consumption kWh/(m²)</td><td colspan="2">186.83</td><td>467.08</td></tr>
<tr><td colspan="3">Source to Site Conversion Factor (Electrici</td><td colspan="3">0.297</td></tr>
<tr><td colspan="6">Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐ Plug</td></tr>
<tr><td>Building energy codes or standards</td><td colspan="6">Minnesota, heating, lighting, plug</td></tr>
<tr><td colspan="7">Energy saving approaches（Yes for√）</td></tr>
<tr><td rowspan="4">Passive Approaches</td><td>Skylight</td><td>Solar Tubes</td><td colspan="2">Thermal Zoning</td><td colspan="2">Passive Solar Heat Gain</td></tr>
<tr><td></td><td></td><td colspan="2"></td><td colspan="2">√</td></tr>
<tr><td>Site Vegetation</td><td>Natural Ventilation</td><td colspan="2">Ground Cooling</td><td colspan="2">Sun shading</td></tr>
<tr><td></td><td>√</td><td colspan="2"></td><td colspan="2">√</td></tr>
<tr><td rowspan="5">Active Approaches</td><td>Energy Efficient Lighting</td><td>Advanced Lighting Controls</td><td>Efficient Appliances</td><td>Load Management</td><td colspan="2">Mechanical Air Heat Recovery</td></tr>
<tr><td>√</td><td>√</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>Displacement Ventilation</td><td>Radiant Heating</td><td>Radiant Cooling</td><td>Air Source Heat Pump</td><td colspan="2">Hot Water Heat Recovery</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>Other</td><td colspan="5">ground source heat pump</td></tr>
</table>

APEC Nearly (Net) Zero Energy Building
Best Practices Information Collection Template

Basic Information			
Building Name	Woods Hole Research Center	Location (City)	Falmouth
Building Type	☐Residential ☐Office ☐School ☐√Others (Please Specify) Laboratory		
Heating Degree Day	4598	Cooling Degree Day	1178
Net Floor Area (m^2)	1784	Treated floor area (m^2)	1784
Number of storeys	3 F/ BF	Completion Date	June 2003
3Incremental Cost Allocation (%)	☐Passive approaches (%) ☐Active approaches (%) ☐Renewable energy system (%) ☐Control system (%)		
Source of Incremental Cost	☐Government Subsidy (%) ☐Project Incentive (%) ☐√Self-fund (%) ☐Donation/Industry in-kind support (%)		

Key Technical Indexes			
Energy consumption	**Energy Consumption Targets**	**Design Value**	**Average value for typical**
	Annual Heating Demand (kWh/m²a)		
	Annual Cooling Demand (kWh/m²a)		
	Primary Energy Consumption kWh/(m²)	**169.84**	**679.37**
	Source to Site Conversion Factor (Electricity)	**0.297**	
	Primary Energy Consumption Including:☐Heating/Cooling ☐Lighting ☐Plug		
Building energy codes or standards	**Massachusetts, heating, cooling, lighting, plug**		

Energy saving approaches (Yes for√)				
Passive Approaches	Skylight	Solar Tubes	Thermal Zoning	Passive Solar Heat Gain
	√			√
	Site Vegetation	Natural Ventilation	Ground Cooling	Sun shading
		√		√

Active Approaches	Energy	Advanced	Efficient	Load	Mechanical Air Heat

	Efficient Lighting	Lighting Controls	Appliances	Management	Recovery
	√	√	√		
	Displacement Ventilation	Radiant Heating	Radiant Cooling	Air Source Heat Pump	Hot Water Heat Recovery
	Other	Ground Source Heat Pump			

Appendix IV

Meeting notes of 1st workshop

(Montreal, Canada)

APEC-CZEBS- iiSBE Net Zero Built Environment Symposium

NSERC SMART NET-ZERO ENERGY
BUILDINGS STRATEGIC
RESEARCH NETWORK

Smart Net Zero Resilient Buildings and Communities

APEC-CZEBS- iiSBE Net Zero Built Environment Symposium

NZEB best practices analysis report of the 1st workshop

20-21 August, 2015

APEC-CZEBS- iiSBE Net Zero Built Environment Symposium

Content

Overview

This Symposium is consisted of two workshops (Aug. 20 and 21), with nearly 70 speakers and delegates from 16 countries, as well as 40 graduate students from Centre for Zero Energy Building Studies (CZEBS), Smart Net-zero Energy Buildings strategic Research Network (SNEBRN), International Initiative for a Sustainable Built Environment (iiSBE) and Asia-Pacific Economic Cooperation (APEC) participated through presentations and discussions on the latest progress on NZEB Best Practices, as well as enabling technologies. The workshop of August 20, focused on case studies, policy issues and an education session and included nearly 20 delegates funded by APEC. The workshop on August 21 focused mainly on enabling technologies for net-zero buildings and communities with participation of about 15 SNEBRN researchers, iiSBE and APEC delegates. The event was organized under the collaboration of CZEBS, iiSBE and APEC. As a continuation of the APEC project EWG 03 2013A: Building Code Harmonization in Energy Smart Community, and further step of project EWG 02 2015A: APEC Nearly (Net) Zero Energy Building Best Practices and Energy Reduction Results Comparative Study, this Symposium also aimed at influence expanding and information collection. This report includes inputs from SNEBRN students coordinated by Dr Remi Charron.

As the co-organizer and funder of the Symposium (workshop on August 20), **Asia-Pacific Economic Cooperation (APEC)** is taking more and more concentration on promoting building energy efficiency among its member economies. APEC has 21 member countries and is the premier Asia-Pacific economic forum whose goal is to support sustainable economic growth and prosperity in the Asia-Pacific region. APEC's initiatives aim to turn policy goals into concrete results and agreements into tangible benefits. APEC has a number of Expert Groups working in different areas, including one on Energy Efficiency and Conservation. APEC helps fund specific projects in collaboration with the various member groups that are relevant to net-zero energy buildings, including APEC-funded project EWG-02-2015A: APEC-NZEB Best Practices.

The venue of this Symposium, **Concordia University Centre for Zero Energy Building Studies (CZEBS)**, whose mission is to reduce the environmental impact of buildings while enhancing their safety and comfort. The meeting was in line with one of its main priorities, which is to facilitate collaborative research aimed at widespread adoption of optimized net-zero energy building (NZEB) design and operation concepts. The Symposium was co-chaired by Dr

Andreas Athienitis and Dr Bruno Lee.

The **NSERC Smart Net-zero Energy Buildings Strategic Research Network (SNEBRN)** is currently the major Canadian research effort in smart net-zero energy buildings. It brings together 30 Canadian researchers from 15 universities to develop the smart net-zero energy homes and commercial buildings of the future. The Network also includes researchers and experts from CanmetENERGY Natural Resources Canada (NRCan) and Hydro-Québec. Industrial partners from the energy and construction sectors are involved in most projects, developing the know-how that will help them compete in the global market. About 55 SNEBRN researchers, partners and students participated in the workshop.

International Initiative for a Sustainable Built Environment (iiSBE) co-organized this event and is an international non-profit organization whose overall aim is to actively facilitate and promote the adoption of policies, methods and tools to accelerate the movement towards a global sustainable built environment. One of their most important activities, which were facilitated by this workshop, is to support networking activities that help specialists and generalists become familiar with each other's abilities and needs.

This report provides a summary of the key outputs of the Smart Net Zero Resilient Buildings and Communities, APEC-CZEBS-iiSBE Net Zero Built Environment 2015 Symposium and meanwhile, shows a brief introduction of the further work of APEC project EWG-02-2015A: APEC-NZEB Best Practices.

Background

The APEC Nearly/Net Zero Energy Building Program responds to the 25th APEC Ministers Meeting and 21st APEC Economic Leaders' Declaration, to reduce APEC's aggregate energy intensity by 45 % by 2035, using 2005 as a base year, and promote clean, renewable and sustainable use of energy within APEC region.

Recently, some APEC developed economies set the goal to achieve Nearly (Net) Zero Energy Building (NZEB) and already launched some research programs and accomplished successful demonstration projects. So, during the 41th Expert Group Meeting of Energy Efficiency and Conservation under APEC Energy Working Group in 2013, Co-sponsored by Hong Kong, China, Singapore, Canada, Japan and Thailand, People's Republic of China proposed this idea of sharing latest progress on NZEB across the APEC region and gets the support from APEC.

The objective of the project EWG 03 2013A is to share the existing experiences and best practices of NZEB to promote this idea among APEC region, which including (1) Exchanging each economy's latest policy and national goals (2) Comparison of different but similar definition of NZEB (3) Sharing Valuable experiences from the demonstration projects and (4) Find Obstacles and barriers to promote NZEB.

Two workshops were held within the project, first was held on October 30th to 31st 2013, 60 participants from 13 economies attended the workshop, the first workshop focus on policies and definitions, research programs and latest technology progress and how building codes upgrading influence the work of NZEB.

80 participants from 15 economies attended the second workshop on October 22nd to 23rd 2014, second workshop focus on monitoring results of pilot project and community and how to promote NZEB in the future in APEC region. Besides speakers and APEC economy representatives, lots of NGOs also were invited to the workshop. Including IFC, UNDP, World Bank, WWF and EF. During the implementation of the program, an NZEB technical working group across the APEC region was established.

NSERC Smart Net-zero Energy Buildings Strategic Research Network of Canada, Architecture 2030 and Lawrence Berkeley National Laboratory of United States, The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan, Nearly Zero Energy Building Alliance of China and Korea Institute of Civil Engineering and Building Technology all helped a lot to support this Program. We would like to welcome more related stakeholders will join this network during the implementation of this project to make the network more extensive and influential.

In the final report of the Phase one, the Long and Mid Term National Goal of NZEB, National Research Team and Stable Funding, Building Codes Upgrading towards NZEB, Financial Support and Subsidy, Energy Reduction Potential of Demonstration Projects, Positive Social & Energy & Environment Influence, Definition Harmonization in the Future, Networks and Organizations are concluded according to different economies.

Also, a series of recommendations are also proposed during the final report:

GOVERNMENT

- Set a long-term, aggressive national target to zero energy buildings with a clear mid-term objective for every step. The goal will support the R& D of research academies and give forward-thinking companies a boost for business planning.
- Financial incentives and subsidy for the pilot and demonstration projects.
- Funding in different climate zones to find the best technology and roadmap to achieve NZEB.
- Harmonize the definition of related terms which will be widely used in the government policies and future action plans.

RESEARCH ACADEMIES

- Kick-off R & D programs which cover passive technology, active technology, renewable energy system, and energy monitoring and management system and technology integration should be
- Testing, evaluation and certification the existing projects that was built with the goal to achieve nearly (net) zero.
- Participate in the continuous improvement of building energy code.
- Deep involvement in the pilot and demonstration buildings.

The phase one report of the program was highly evaluated by the APEC Energy Working Group and could be find in the APEC website here and it had been downloaded for more than 2000 times.

Successful demonstration projects are the most powerful way to promote NZEB in building sector. With the successful demonstration projects that could achieve 75%-90% energy reduction compared with the ordinary building, all stakeholders could be influenced and benefitted, the government officers and building energy codes management organization could find the way to raise up the minimum requirement of building energy consumption step by step, architects and engineers could see and learn the latest building energy efficiency technology progress, also could call for public awareness.

So, with the APEC continuous funding support, the second stage of the program (Phase II:EWG 02 2015A) is ongoing. Phase II focus on Best Practices Study, which will carry out professional in-depth comparative research with the detail information collected of best practices of NZEB pilot buildings among APEC economies, to showcase how tremendous energy savings could be achieved by integrated design, advanced technology utilization and NZE oriented management & commissioning in buildings.

The specific objectives are:

1) To prepare a comprehensive and systematic information collecting template on existing NZEB demonstration projects that could cover complete and necessary information of the target project. The template could also be used for future APEC related studies.

2) To carry out comparative study of different NZBE pilot projects' best practices, including commercial buildings and residential buildings in all climate regions among APEC economies. The technologies of passive design, active energy system, building fenestrations and renewable energy systems will be collected and building energy consumption reduction results will be compared with the average level.

3) To host two workshops. Experts and stakeholders from APEC member economies will be invited to discuss the main challenges and risks during the design, construction and operation of Net Zero Energy commercial building and residential building, experiences and suggestions of how to deal with those problems.

4) To finalize the report <APEC Nearly (Net) Zero Energy Building Best Practices>, the report could be used as a guidebook of NZEB design to support the technology research and development and marketization in APEC regions. The report will be shared on the APEC website after the project is completed.

As one of the fruitful outcome of this project, NZEB best practices information collection was thought to be the critical stage. This Symposium successfully support the latest NZEB related information sharing and collection, which effectively help the formation of NZEB best practices information collection template.

Highlight

The symposium included four plenary speakers and from 3 to 5 speakers on eight different Panels discussing a range of topics from individual technologies, to communities and their interaction with the grid and policies, standards, incentives and education needed to accelerate the adoption of net-zero energy buildings. The plenary speakers and their topic areas tied all of the research together that was presented in the panels.

In the opening plenary session, Dr Paul Torcellini discussed how to make net-zero buildings mainstream by presenting lessons learned from the new NREL facility in Colorado, the largest net-zero energy building in the world. By having clear objectives in the RFP including mission critical objectives (e.g. LEED Platinum), highly desirable objectives (e.g. max 25 $kBTU/ft^2$ energy consumption) and "if possible" objectives (e.g. net-zero energy), design teams were able to innovate and develop a design that would meet net-zero energy consumption at a lower cost than similar conventionally built buildings.

Edward Mazria's plenary discussed the importance of moving the building stock to have net-zero carbon emissions by 2050 and presented a path to get there for new and existing buildings as well as the building components. In order to have an 85% chance for global warming to stay below 2ºC, global emissions need to peak soon and go down to zero by 2050. This highlighted the importance of the research work being done, advancing the state of net-zero energy buildings.

Dr Andreas Athienitis' plenary discussed Network key research achievements, as well as a number of challenges that remain. He stressed that more work needs to be done to integrate solar technologies with energy efficiency, with the building architecture and the building envelope itself. This would need to make use of more intelligent building operation that employs predictive control, and that the focus would need to not only be on energy conservation, but also on peak load shifting and reduction. There is a need to continue to develop building integrated PV systems with thermal energy capture in order to maximize the amount or renewable energy that could be captured and utilized from the building envelope in order to achieve net-zero energy targets in larger multi-storey buildings.

In the final plenary, Nils Larsson discussed his vision of how clusters of buildings could work together to make achieving the required energy savings more achievable. Prospects at the scale of building clusters offer the potential of inter-building synergies. Synergy zones could benefit from optimization of supply and demand of thermal energy, DHW, grey water, and DC power from building of different uses (residential, office, retail, schools, etc)

The panelists presented a number of different net-zero and near-zero building demonstration projects and case studies; everything from a single house, to large commercial buildings and small communities. There were many similarities between the different projects. There is a need to optimize passive elements first, with an emphasis on passive solar, daylighting and natural ventilation. This is followed by trying to maximize the energy efficiency of lighting and HVAC systems. Finally renewable energy technologies are introduced. The design also needs to consider optimal operation of the building through control strategies, as well as implementing continuous monitoring and commissioning. These similarities existed despite the different locations. Although differences in climate, energy mix and local political will have an influence on a number of design attributes. There were also a number of presentations that discussed the importance of codes and standards and these will be key in accelerating the adoption of net-zero energy buildings.

Related engineering and architecture programs need to be updated in order to train the architects and engineers to work seamlessly as a team. Not only do architects need to better consider the engineering aspects, engineers need to consider the architectural impact of their technologies. Only through tight integration at early design phase, a truly resilient net zero built environment can be designed and implemented. In fact, the sentiment is that there is no fundamental conflict between any of the architectural / social-cultural values of the design and the technical considerations of the implementation. However, there is a lack of a common language that could translate conceptual ideas across different professions and a platform that could facilitate exchange in a quantitative manner. Research work is needed to develop such language and platform. The education system also plays a crucial role in engaging both architectural and engineering students as a team through project based learning and studio work.

There were a number of presenters that discussed the importance of considering resilience in building design. Net-zero energy buildings are by nature more resilient than standard construction practices. However, with additional focus on resilience, buildings could be better prepared to adapt and respond to our changing climate.

Symposium Program

Thursday August 20, 2015 Location: EV 2.260

NZEB *Case Studies, Best Practices, Policies and Education Issues*

8:00 AM - 8:45 AM	**Registration & Light Breakfast**
8:45 AM - 9:00 AM	**Introduction** • *Dr Andreas Athienitis*, Director, Centre for Zero Energy Building Studies, Concordia University • *Nils Larsson*, Executive Director, International Initiative for a Sustainable Built Environment • *Prof Wei Xu*, APEC NZEB Program Overseer. Director of China NZEB Alliance. China Academy of Building Research
9:00 AM - 9:30 AM	Welcome from *Dr Benoit-Antoine Bacon*, Provost, Concordia University **Plenary Speaker: Dr Paul Torcellini, Ph.D.,** Associate Professor, Eastern Connecticut State University *Moving the Mainstream towards Net-Zero Buildings*
9:30 AM - 10:45 AM **Chairs:** Josef Ayoub TBA	**Panel 1: NZEB and Low Energy Building Case Studies and Practices** • *Sonja Winkelmann*, Canadian Home Builders' Association *The Acceleration of Net Zero: How the Canadian Home Builders' Association is Supporting Industry Innovation* • *Dr Lantz Holtzhower*, Construction Management Technology, Oklahoma State University *Examining Initial Steps and Barriers to Net Zero in the State of Oklahoma* • *Hamed Hakim*, Powell Center for Construction & Environment, University of Florida *Net-Zero Energy Schools Case Studies: The Starting Block for the Canadian Energy Neutral K-12 Schools* • *Dr Dongwoo Cho*, National Green Building, Center Korea Institute of Civil Engineering and Building technology *Design, Construction, Operation & Monitoring of Zero Carbon Green Home* • *Dr Gao Chun Ping*, Building and Construction Authority, Singapore *Leading the Way to Net Zero: Best Practice of Asia's first retrofitted zero energy building*
10:45 AM - 11:00 AM	**Break:** Atrium, EV Building
11:00 AM-12:30 PM **Chairs:** Alan Fung Meli Stylianou	**Panel 2: NZEB and Low Energy Building Design Practices** • *Dr Suwon Song*, Building and Urban Research Institute, Korea Institute of Civil Engineering and Building *Best Practice for NZEB - Seoul Energy Dream Center of Korea* • *Dr Gyuyoung Yoon*, Nagoya City University, Japan *nZEB Oriented Best Practices in Japan* • *Dr Carolyn Szum*, Lawrence Berkeley National Laboratory *Best Practice of Green Building Development in Sub-tropic Climate in China* • *Dr Yu Zhen*, Institute of Building Environment & Energy, China Academy of Building Research (CABR) *Design and Operation of CABR Nearly Zero Energy Building* • *Dr Wim Boydens*, Studiebureau Boydens, Belgium *The Solarwind Pilot Building in Operation as Driver for Research* • *Michael Lio*, buildABILITY Corporation, Canada *Affordable Net Zero Housing Communities in Canada: The Owens Corning Canada National Net Zero Project*
12:30 PM -1:30 PM	**Lunch:** Atrium, EV Building
1:30 PM - 2:00 PM	**Plenary Speaker: Edward Mazria, AIA, Hon. FRAIC,** Founder and CEO, Architecture 2030 *Road to Zero*

2:00 PM - 3:15 PM **Chairs:** TBA Shicong Zhang	**Panel 3: Policies, Standards and Incentive Measures for Net-Zero Energy Building and Communities** • Dr Hideharu Niwa, Nikkenn Sekkei Research Institute, Japan *Overview of NZEB in Japan - Discussion on Definition and Evaluation Method of NZEB in SHASE of Japan* • Dr Wei Pan, Department of Civil Engineering, University of Hong Kong *Where to Draw Socio-Technical System Boundaries of Zero Carbon Buildings and Communities?* • Dr Michael Emmer, School of Engineering, Computing & Construction Management, Roger Williams University *Embodied Energy of Net-Zero Energy Buildings: A Holistic Examination* • Dr Shicong Zhang, Institute of Building Environment and Energy, China Academy of Building Research *Research on Performance Criteria of Nearly-Zero Energy Buildings In China*
3:15 PM - 3:30 PM	**Break:** Atrium, EV Building
3:30 PM - 4:30 PM **Chairs:** Bruno Lee Carmela Cucuzella	**Panel 4: Education for Net-Zero Energy: Challenges for Architecture and Engineering Programs** • Ann Edminster, Design AVEnues *LLC*, Pacifica, California *Educational Needs for Architects & Engineers to Consistently Create Smart Net-Zero Resilient Projects* • Dr Carmela Cucuzzella, Design and Computation Arts Department, Concordia University *When Environmental Evaluation meets Architecture Critique* • Dr Michael Jemtrud, School of Architecture, McGill University *The Architecture Design Studio and High-Performance Building: Challenges and Reflections* • Dr Bruno Lee, Department of Building, Civil & Environmental Engineering, Concordia University *Preparing Future Engineers to Collaborate in a Multidisciplinary Environment*
4:30 PM - 5:45 PM	Tour A: Concordia P. Fazio Solar Simulator – Environmental Chamber Laboratory Tour B: John Molson Building – Building Integrated Photovoltaic/Thermal System
6:00 PM	Symposium Panellist Dinner

Friday August 21, 2015 Location: EV 2.260

NZEBs, Communities and Enabling Technologies

9:00 AM - 9:30 AM	Welcome from Dr Amir Asif, Dean of Engineering & Computer Science, Concordia University **Plenary Speaker: Dr Andreas Athienitis, Ph.D., P.Eng., FCAE** *Dr* Andreas *Athienitis*, Director, Centre for Zero Energy Building Studies, Concordia University *Towards Net-zero Energy Buildings and Communities: Challenges and Opportunities*
9:30 AM -10:45 AM **Chairs:** Chris Kennedy Caroline H-Vermette	**Panel 5: Design of Net-Zero Resilient Communities** • Dr Caroline Hachem-Vermette, Faculty of Environmental Design, University of Calgary *Towards resilient development: Canadian initiatives* • Dr Scott Bucking, Department of Civil and Environmental Engineering, Carleton University *Net-Zero Resilient Communities: Three Canadian Case-Studies* • Dr Miguel Aloysio Sattler, Federal University of Rio Grande do Sul, Dept of Civil Engineering, Brazil *A Happy Community's Search for Resilience*
10:45 AM-11:00 AM	**Break:** Atrium, EV Building
11:00 AM - 12:00 AM	**Panel 6: Building Integrated Solar as an Enabling Technology for Net-Zero Energy and Resilience** • Dr Soteris Kalogirou, Dept of Mech Engineering and Materials Science and Engineering, Cyprus University of Technology *Building Integrated Solar Thermal Systems: Technology Appraisal*

Chairs: Stephen Harrison Soteris Kalogirou	• *Dr Christophe Ménézo,* Chair INSA-EDF/Fédération sur l'Energie Solaire - FédEsol FR 3344/USMB, France *Building Integrated PV-thermal collectors and systems* • *Dr Annamaria Buonomano*, Dept. of Industrial Engineering , University of Naples Federico II, Italy *Modelling PCM, BIPV/T and other innovative technologies for energy efficiency in buildings: a case study* • *Dr* Esteban *Zalamea León*, Department of Design and Theory of Architecture, University of Bío Bío, Chile *Assessment of roof capacity for active solar energy generation in Housing Developments*
12:00 AM - 1:00 PM	**Lunch:** Atrium, EV Building
1:00 AM - 1:30 PM	**Plenary Speaker: Nils Larsson, FRAIC** Nils Larsson, Executive Director, International Initiative for a Sustainable Built Environment *Systems model for small urban zones*
1:30 PM - 3:30 PM **Chairs:** Radu Zmeureanu Sophie Hossatte	**Panel 7: Energy Efficiency Technologies and their Integration with Renewables** • Dr *William O'Brien*, Department of Civil and Environmental Engineering, Carleton University *Design of resilient and robust high-rise residential buildings* • *Dr Umberto Berardi*, Faculty of Building Science, Ryerson University *The development of mPCM enhanced tile for high performance buildings* • *Dr Hua Ge*, Department of Building, Civil & Environmental Engineering, Concordia University *High performance building envelopes for Smart net-zero resilient buildings* • *Dr Ted Stathopoulos*, Department of Building, Civil & Environmental Engineering, Concordia University *Wind Energy Potential of Urban Areas* • *Dr Alan Fung*, Department of Mechanical and Industrial Engineering, Ryerson University *BIPV/T + ASHP: Technologies for Near and Net-Zero Energy Buildings* • *Dr Li Huai*, Institute of Building Environment & Energy, China Academy of Building Research *Performance analysis of GSHP system in CABR nearly zero energy buildings (NZEB)*
3:30 PM - 3:45 PM	**Break:** Atrium, EV Building
3:45 PM - 5:00 PM **Chairs:** Jose Candanedo Jocelyn Millette	**Panel 8: Optimizing Building Operation, Storage and Grid Interaction** • *Dr Cynthia Cruickshank*, Dept of Mechanical and Aerospace Engineering, Carleton University *Heat Pump Water Heating Control Strategy Optimization for Cold Climates* • *Dr Lukas Swan*, Department of Mechanical Engineering, Dalhousie University *Energy storage will enable net-zero energy buildings to become mainstream* • *Dr Liangzhu Wang*, Department of Building, Civil & Environmental Engineering, Concordia University *Modelling and Design of Natural and Hybrid Ventilation Systems for High Performance Buildings* • *Justin Tamasauskas*, Natural Resources Canada, CanmetENERGY-Varennes *Advanced Control of Heat Pumps and the Impact on Building/Grid Interactions*
5:00 PM - 6:00 PM	**Closing Discussion – Main Symposium Points**

Key Points from Presentations

Panel 0: Introduction

0-1 Moving the Mainstream towards Net-Zero Buildings

Paul A. Torcellini, Ph.D., P.E. Associate Professor, Eastern Connecticut State University

- Definition of Zero Energy Building: 1) Zero Energy Building (ZEB); 2) Zero Energy Campus; 3) Zero Energy Portfolio; 4) Zero Energy Community.
- Largest NZEB in the world – NREL Colorado.
- Trends for Commercial sector have seen substantial gains in energy efficiency in the past, but growth in new buildings has increased faster leading to a net-increase in energy consumption (Figure 0-1-1).

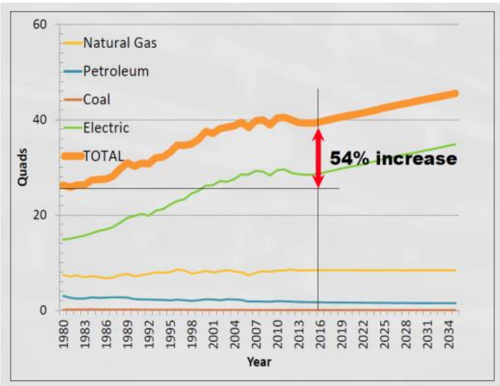

Figure 0-1-1

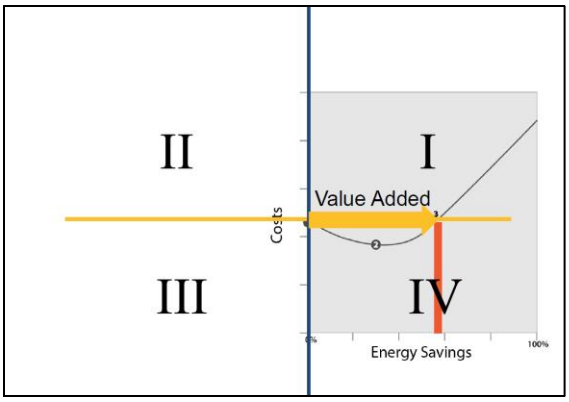

Figure 0-1-2

- Presented Great Potential in Commercial Buildings shows the variation of building energy consumption from the existing state of commercial buildings standard (2003 CBECS) –new buildings base scenario (Standard 90.1-2004) – Max Tech energy efficient scenario—Max Tech energy efficient scenario.
- Progression of energy savings goals have seen them becoming measurable (green building, LEED, 30% less than ASHRAE 90.1-2004, design buildings to use less than 25 kBTU/ft2, design net-zero.
- Presented a graph (Figure 0-1-2) with 4 quadrants x-axis (energy savings) – y-axis (costs) stating that we should put more focus on bottom left (less costs, less energy) instead of top right (high cost, less energy).

- Problem definition is key. Nee clear RFP Objectives with prioritized goals (e.g. mission critical – LEED platinum, highly desirable – 25 kBTU/ft2, if possible, net-zero energy)
- Show a design-build process to achieve the RFP Objectives: 1. Owner made tough decisions up-front(set budget, Sought maximum value for that budget, Prioritized goals); 2. Design-Build procurement process; 3. Allowed design-build team to use creativity to maximize value
- Strong leadership and management is the critical point to replicate the process .
- Lower cost than other similar conventionally built buildings (Figure 0-1-3).
- Actual consumption matches modelled predictions (Figure 0-1-4).

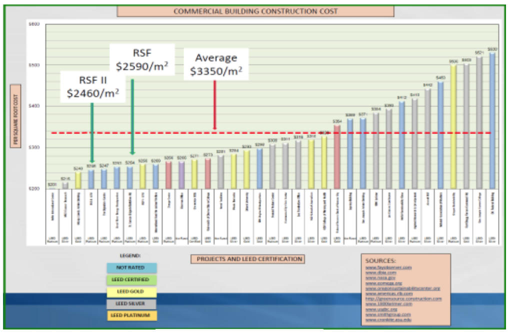

Figure 3

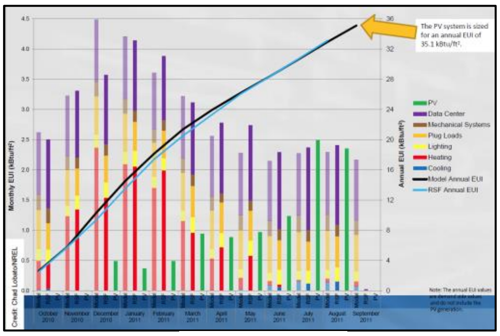

Figure 4

0-2 Road to Zero—Why? When? What? How?

Edward Mazria FAIA, FRAIC. Architecture 2030

- Show “Pathways for Fossil Fuel Carbon Emissions to 2100”--The global carbon emissions will achieve its peak by 2016.
- Urban environments are responsible for 75% of all human-produced global greenhouse gas emissions, among which Building products: 2015 – 35%, 40% 2020, 45% 2025, 50% 2030
- Emissions peak , eliminate CO2 emissions by 2070 to have 66% chance of staying below 2ºC
- Emissions peak by 2020, phase out by 2050 gives an 85% chance of keeping below 2ºC
- Equivalent of one NYC worth of building areas added every 35 days until 2030
- By 2030, over80 billion m2 (900 billion ft2) of new and rebuilt buildings will be constructed in urban areas worldwide.
- Present the 2030 challenge (Figure 0-2-1) and roadmap 2050 (Figure 0-2-2) (www.2030palette.org for online resource)

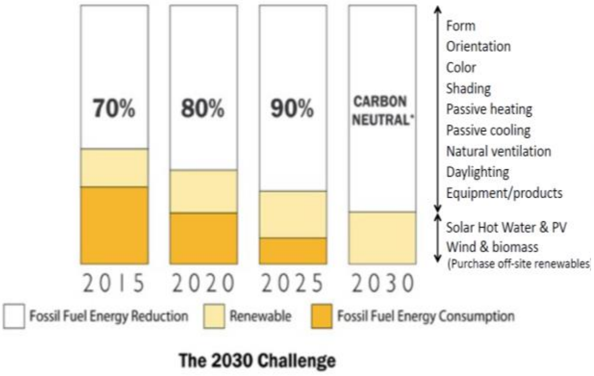

Figure 0-2-1

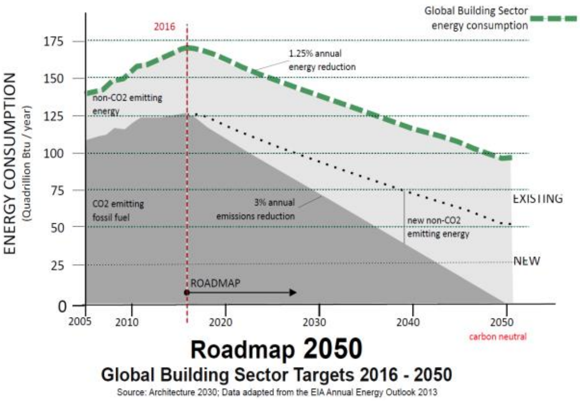

Figure 0-2-2

- Architecture 2030 set a collaboration with 70% of the top 20 A/E firms, 54% of the U.S A/E firms, and 63% of U.S A/E firms believe they can meet the 2030 Challenge targets(DI survey).
- By 2030, over 80 billion m2 of buildings will be built new and rebuilt in urban areas worldwide, Global building construction during this period is projected to occur 38% in China; 15% in U.S. / Canada; 9% in India
- Its publication Road to Zero Emissions focuses on the design of the United Nations Framework Convention on Climate Change (UNFCCC) 2015 agreement, with a goal of reaching a new agreement to prevent dangerous climate change, applicable to all countries, by keeping global average temperature increases under 2°C above pre-industrial levels.
- Roadmap 2050 guidelines and action items for developed and developing countries to formulate custom Building Sector CO2 emissions reduction schedules to 2050.
- Show various carbon emission savings (Figure 0-2-3) and budget savings (Figure 0-2-4) with different building operations from 2005-2030.
- Sefeira – real-time energy simulation of the building during design. Needed with quicker turnaround times, especially in China seeing 3 mth from design to construction

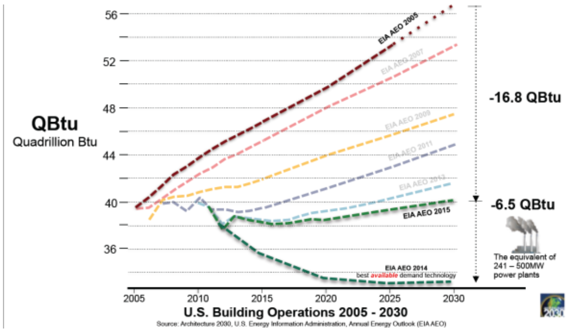

Figure 0-2-3

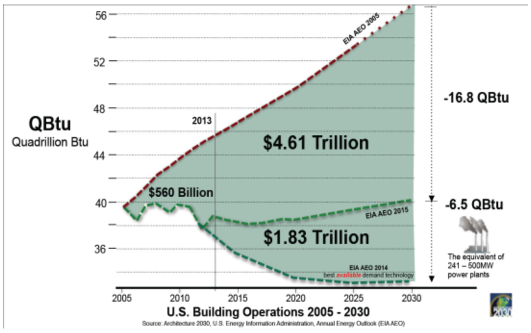

Figure 0-2-4

- The International Union of Architects (UIA), representing over 1.3 million architects in 124 countries, announced that it had unanimously adopted the 2050 Imperative.
- The Carbon Neutral Cities Alliance is a new collaboration of international cities committed to achieving 80% emissions reductions by 2050 or better.
- New York City is planning to overhaul the energy-efficiency standards of its buildings in order to decrease the greenhouse gas emissions by 80 percent by 2050 from 2005 levels.

0-3 Towards Smart Net-zero Energy Buildings and Communities: Challenges and Opportunities

Dr *Andreas Athienitis*, Ph.D., P.Eng., FCAE, Director, CZEBS, Concordia University, Canada

- Net-zero buildings need to be smart, as they will be interacting with the smart-grid
- Quote with ASHRAE vision 2020: NZEBs are becoming adopted by many countries as a long term target
- Put up with the path to net-zero: promotes an integrated approach to energy efficiency and renewable.
- The major international trends in high performance buildings includes: 1. reduce and shift peak electricity demand from buildings; 2. efficiently integrate new energy technologies
- Explain the main differences between current buildings and future smart net –zero energy building from four parts: 1. Building fabric; 2. Heating and Cooling; 3. Solar systems/renewables; 4. Building operation
- SNEBRN put up with its vision: to perform the research that will facilitate widespread adoption in key regions of Canada, by 2030, of optimized NZEB energy design and operation concepts suited to Canadian climatic conditions and construction practices.

- SNEBRN put up with its goal: Investigate optimal pathways for reaching net-zero energy at building and neighborhood levels through combinations of passive systems and active technologies.
- NSERC Smart Net Zero Energy Buildings Strategic Research Network involves researchers from SBRN, and other partner institutes with 5 themes: 1. Integrated solar and HVAC systems for buildings; 2. Active building envelope systems and passive solar technologies; 3. Mid-to long-term thermal storage for buildings and communities; 4. Smart building operating strategies; 5. Technology transfer, design tools and input to national policy.
- Smart NZEB concept-- Optimal combination of solar and energy efficiency technologies and techniques provides different pathways to reach net-zero
- EcoTerra™ EQuilibrium™ House (AlouetteHomes)
- Athienitis house-- Passive air circulation in BIPV/T melts snow in winter
- JMSB BIPV/T SYSTEM
- Varennes NZEB Library design (Montreal)

0-4 A systems model for small urban zones that may bring us closer to nearly-zero

Nils Larsson, FRAIC, Executive Director, iiSBE

- iiSBE website: See www.iisbe.organd http://iisbecanada.ca
- NZEB more readily achievable, but new buildings are small part of building stock, and meeting net-zero for entire building stock very difficult, if not impossible.
- Prospects at the scale of building clusters offering the potential of inter-building synergies.
- Set up a concept model Synergy Zones to present the potential role of very small urban areas, or building clusters in the form of synergistic performance in energy consumption, emissions and water consumption and other less critical issues.
- Synergy zones could benefit from optimisation of supply and demand of thermal energy, DHW, grey water, and DC power from building of different uses (residential, office, retail, schools.)
- Provide a diverse occupancy profiles provide opportunities (user profiles for an office, restaurant, hotel, and classroom).

- Building occupancy type and area determine the demand for space heating, consumption of potable and greywater, leading to surpluses or deficits.
- For further development, the Synergy Zone model needs to be further evaluated; pilot would help work out details. A concept is presented that builds on these ideas, in the aspect of study.
- Working at the scale of urban clusters of buildings offers the prospect of inter-building synergies in thermal energy, greywater and DC power systems, and this provides a realistic possibility of moving closer to nearly zero performance levels
- Post-Occupancy Evaluation
- SBTool
- IDP-Integrated Design Process

Panel 1: NZEB and Low Energy Building Case Studies and Practices

1-1 Design and Operation of CABR Nearly Zero Energy Building

Dr Zhen Yu, Institute of Building Environment & Energy, China Academy of Building Research (CABR)

- China is the biggest market of Green Building which owns a great increase of certified green buildings. Number of ZEB demonstration projects, in various climate zones (with most currently under construction)
- CABR IBEE set up the target 25 kWh/m2 (zero use of fossil fuel for heating in winter and cooling energy consumption reduced by 50% in summer), low construction costs in China makes it difficult to build actual net-zero buildings. Instead aiming for near zero energy buildings.
- Completed 2014-07-11, one year of energy data now available.
- Building itself is a comprehensive research platform with different HVAC possibilities/configurations and lots of instrumentation to monitor actual performance.
- Present a detailed analysis on actual performance data, including energy consumption, measurement verification, seasonal thermal storage, and GSHP
- Actual HVAC + lighting (22 kWh/m2), pump energy consumption higher than expected, continuous monitoring & commissioning should lead to further reductions.

1-2 Examining Initial Steps & Barriers to Net Zero in the State of Oklahoma

Dr Lantz Holtzhower, Construction Management Technology Department, Oklahoma State University, USA

- Oklahoma Model calls for Energy Economy Balance (from the aspect of natural gas, oil, and coal) and electricity production with renewable energy.
- Oklahoma Energy Security Act 2010 set the goal of 15% renewables by 2015, up to 25% of that from energy efficiency & demand side management. 2014 were at 20.85 RE and 11% from efficiency, lots of RE from large scale wind farms.

- Oklahoma get a good Renewable Potential in wind and solar
- Energy Efficiency measures -- include$4K income tax credits for personal, and corporates are courage to produce renewable energy to decrease the tax credits.
- 2010 all public buildings mandated to be LEED. In2011, reversed by Senate as the state is very protective of its natural gas industry.
- Need baby steps (scale ROI, more wind farms, geothermal neighborhoods, more solar installations)

1-3 NET ZERO ENERGY SCHOOLS: The starting block for the Canadian energy neutral K-12 schools

Hamed Hakim, Powell Center for Construction & Environment, University of Florida, USA

- Sustainable Schools and Green School Concept are adopted in Canada (David Suzuki Public School, Samuel Brighouse Elementary School)
- Many benefits of sustainable school, environmental, economic & environmental
- According to the International Energy Agency (IEA), the building sector is the second largest energy user in Canada.
- Over 18,425 elementary & secondary schools in Canada with mean EUI of 213.9 kWh/m2 (SCIEU, 2009)
- Over 450 LEED registered schools (16% certified, and 2% platinum)

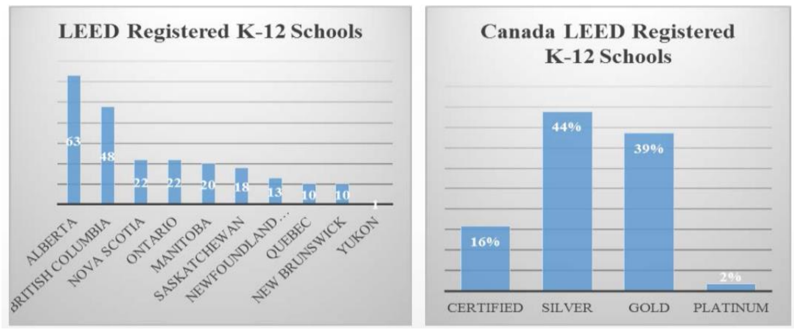

Figure 1-3-1

- DAVID SUZUKI Public School
- SAMUEL Brighouse Elementary School
- Looked at low-energy schools in US with similar climate zones to make suggestions for Canada to reach net-zero energy.
- Many strategies applied to all studied buildings (PV, optimized orientation, natural ventilation, daylighting, geo-exchange, high performance envelope/lighting/HVAC, automated sensors) that should be applicable in Canada making NZES attainable.

1-4 Design, construction, operation & monitoring of Zero Carbon Green Home

Dr Dongwoo Cho, Korea Institute of Civil Engineering and Building Technology

- Korea has set target to reduce the greenhouse gas emissions according to Presidential Committee on Green Growth in 2009. Among which 26.9% GHG reduction in building sector by 2020 and for detailed goas: 1. Low energy house (50% reduction in H/C) in 2012; 2. Passive House (90% reduction in H/C) in 2017; 3. Zero-energy House (ZERO energy) in 2025.
- Passive House criteria and energy saving criteria in Korea
- Policy for promotion of ZEB: 1. to generate many case studies (2014 low-rise, high-rise 2015, towns 2016) and create a market for zero energy buildings; 2. Building standards, tax benefits, technical support to reduce additional costs
- Promotion of integrated planning & design process and frameworks in each phase
- Case study—Zero Carbon Green Home Project: 8 storey-15 unit finished in 2013 (with non-heated space for stairs & elevators). 1. Design, 2. Construction, 3. Operation (3 different operating conditions – artificial occupancy, actual occupancy, simulated occupancy), 4. Energy Monitoring
- Heating energy, typical 9088 kWh/yr, ZCGH 1,884 kWh/yr per unit. ZCGH saves 80% on heating, and 85% on electricity compared to conventional apartments.
- Monthly average PV generation 255 kWh/unit or 85% of the energy demand. Current payback period is 17 years, which should be reduced by incentives and growth in the market.

1-5 Leading the Way to Net Zero：-Best Practice of Asia's first retrofitted zero energy building

Dr Chun-Ping Gao, Building and Construction Authority Singapore

- 2 steps for Guiding Principles: 1. Passive Systems (Efficient envelope, minimise solar heat gain, capitalize daylighting); 2. Active Systems (Efficient Lighting, Efficient ACMV, Active Control)
- For building envelope: insulated core wall, different types of shades, light shelves, vertical greenery, innovative solutions for façade, pioneering use of materials (Solar Assisted Stack Ventilation)

- For inside building: Personalised ventilation, Light pipes, Displacement Ventilation, Single Coil Twin Fan
- Needed to move chiller to neighbouring building to make room for large PV system. Even with whole roof system, didn't have quite enough area for PV. (Also has light tubes and solar assisted stack ventilation that has solar chimney)
- Green wall system important in tropical climates. Reduces external surface temperature, reducing heat flux & energy consumption.
- After 2 years, natural ventilation zones needed to add air conditioning.
- Final energy consumption was less than simulated consumption with most of the difference attributed to lower plug loads. Over 25000 visitors since 2009.
- Future – rotatable laboratory building to be situated on the roof.

Panel 2: NZEB and Low Energy Building Design Practices

2-1 Best Practice for NZEB - Seoul Energy Dream Center of Korea

Dr Suwon Song, Korea Institute of Civil Engineering and Building Technology

- 3762 m^2 demonstration building built in Seoul constructed in 2012
- Combination of Passive Design+ Active Design+ Renewable energy (Figure 2-1-1), energy savings 80% from ECMs, 20% from PV Panels with 272 kWp system (Figure 2-1-2)

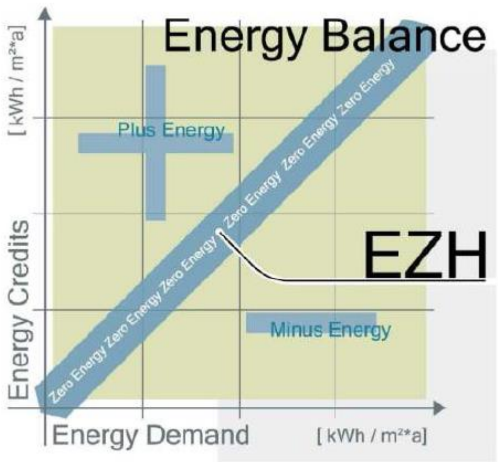

Figure 2-1-1

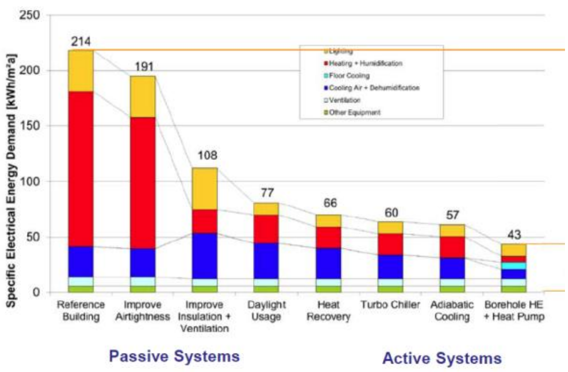

Figure 2-1-2

- Radiant heating and cooling system (commercial EU system) with GSHP
- Heat recovery ventilation systems
- Design conditions for cooling mode: 1. Natural Cooling Mode; 2. Tuber Chiller Operation Mode; 3. Chilled Water Buffer Tank (3,000 L); 4. Cooling Tower for Chiller Operation
- 2013 annual electricity use 40.61 kWh/m2, annual electricity ner-income of $7435/yr
- Savings as expected. Additional savings expected from further commissioning of system.

2-2 nZEB Oriented Best Practices in Japan

Dr Gyuyoung Yoon, Nagoya City University, Japan

- Annual climate variation (temperature, relative humidity) in 3 cities: Naha, Tokyo, Sapporo
- Strategies to achieve ZEB (Passive then Active then RE measures) (Figure 2-2-1)
- Best practices from 21 buildings of various sizes, uses and locations (Figure 2-2-2):Three buildings achieved net-zero energy
- **Fashionable passive measures:** Natural ventilation, Night purge; Solar shading devices; Daylight Utilization; Exhaust air and reuse; Perimeter buffer system
- **Fashionable Active measures:** separate sensible & latent HVAC systems; Radiation H/C system (Ductless system)； Task & Ambient Lighting / HVAC system； LED lighting； Fresh air volume control by CO2 concentration； Large temperature difference water supply； High efficiency heat pump module chiller； Ground heat source heat pump； Desiccant HVAC system； TES

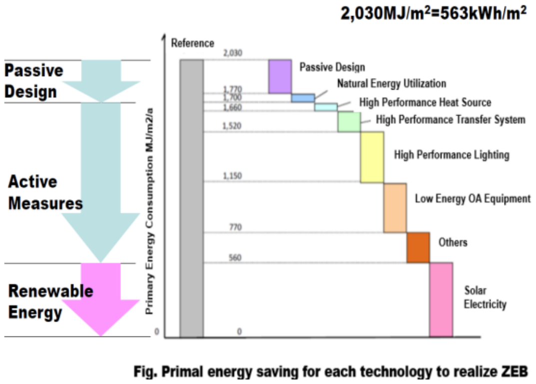

Figure 2-2-1

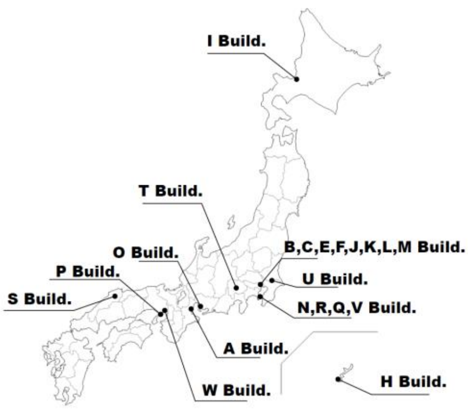

Figure 2-2-2

- One of most important measures is proper energy management and commissioning
- Adapting more energy saving measures, coupled achieve further 40% reduction in consumption. 400 to 600 MJ/m^2 would be a minimum possible value for energy intensity

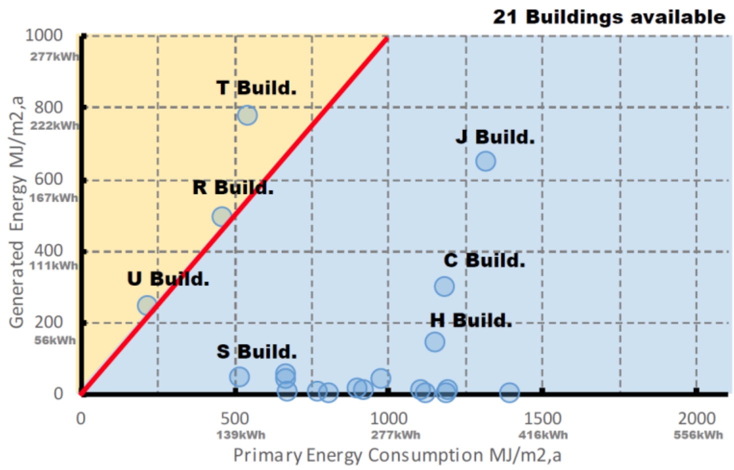

Figure 2-2-3 nZEB oriented Best Practices on ZEB Chart

2-3 Best Practice of Green Building Development in Sub-tropic Climate in China

Carolyn Szum, Lawrence Berkeley National Laboratory, USA

- Shenzhen IBR HQ building located in Shenzhen, Sub-tropic climate with HDD (18C): 227; CDD (18C):2459,
- Total floor space: 18,000 m2 (conditioned 17,600 m2). Annual energy consumption: 60kWh/m2 (large data centre uses up about 1/3 of energy consumption).
- Chinese green building “Three-Stars” label
- 20-30 measures and technologies chosen to be applied to achieve nearly zero energy building among many other project goals (including energy savings, water savings, material savings, IEQ…)
- HVAC system use WSHP for cooling and pilot radiant cooling system
- Natural ventilation used during Non-AC seasons, nearly most of the year
- Integrated PV 3 ways: on rooftop, west façade – semi-transparent thin-film, horizontal placement on façade to serve as solar shading devices. Also have small wind on the roof. RE make up 6% of building energy use.
- Design-Build-Operate model
- Book available at Amazon.com that describes the building

2-4 The Solarwind Pilot Building in Operation as Driver for Research

Prof Wim Boydens, Ghent university / CSTO boydens engineering group, Belgium-Luxembourg-Vietnam

- The Solarwind office building (see general info https://vimeo.com/116782026)
- Designed 2008, inauguration November 2012, 20,000 m2 office building
- Combining multiple Renewable Energy Systems (RES) in 10.000 m² office building
- Optimize control, and one step further is to optimize the design to go with the optimized control.
- Heat supply with 3 renewable energy: 65% of the geothermal, 20% of the biomass, and 15% of the solar for heating
- TABS Emission system: cca (concrete core activation)
- Thermal energy storage on 3 levels –geothermal, building integrated (concrete slabs) and 20 m3 tank
- Building Management System (try to influence users, as well as optimise control to reduce energy). For this type of building they anticipate 2 years of fine tuning and field optimisation.
- Dynamic simulations, commissioning, monitoring, advanced control, optimizing auxiliary energy use
- Previous project: EU-EraSME-GEOTABS project (2011-2013)
- Holistic system approach taking into account dynamic interaction of the components.

2-5 Affordable Net Zero Housing Communities in Canada: The Owens Corning Canada National Net Zero Project

Michael Lio, buildABILITY Corporation, Canada

- Work with builders to mainstream technologies, i.e. making net-zero “Production Builder Friendly”
- Definition of NET ZERO ENERGY HOME: A home that employs enhanced energy efficiency design strategies to cost effectively reduce energy needs, while supplementing with renewable energy technologies, with the result that the building consumes equal to or less energy than it produces on an annual basis

- Project mission: 5 net-zero communities (minimum 5 houses) across the country (1 condo, 1 row, 3 single family projects) to be completed by March 2016
- No direct funds going to the builders
- Ultimate long term goal is to implement net-zero into the building code by 2030

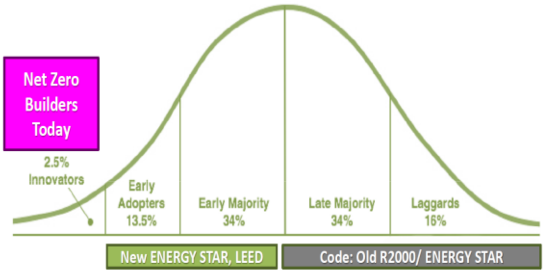

Figure 2-5-1

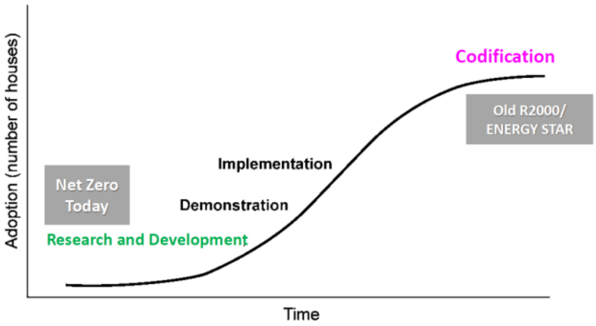

Figure 2-5-2

- Similar design features seen across projects including PV, triple glazed windows, heat pump water heater, cold climate heat pump, home energy monitor (most have R-60 blown attic, R24+R10 XPS for walls)

Panel 3: Policies, Standards and Incentive Measures for Net-Zero Energy Buildings and Communities

3-1 Overview of NZEB in Japan - Discussion on Definition and Evaluation Method of NZEB in SHASE of Japan

Dr Hideharu Niwa, Nikkenn Sekkei Research Institute, Japan

- SHASE Society of Heating Air Conditioning and Sanitary Engineering
- Self-sufficiency of energy recognized from viewpoint of energy security after earthquake.
- **Definition and Evaluation Method of NZEB in SHASE of Japan:** A Net Zero-Energy Building is a building that has a high energy saving through load reduction, natural energy use and high energy efficiency without decreasing the environmental quality both indoor and outdoor.

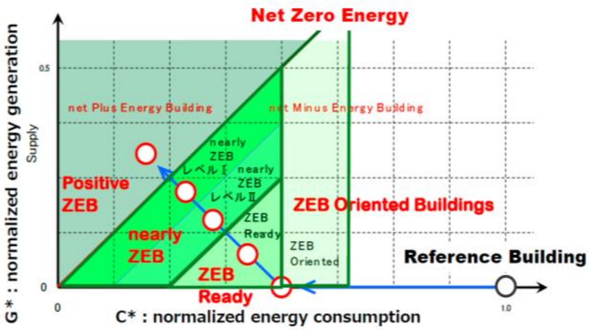

Figure 3-1-1

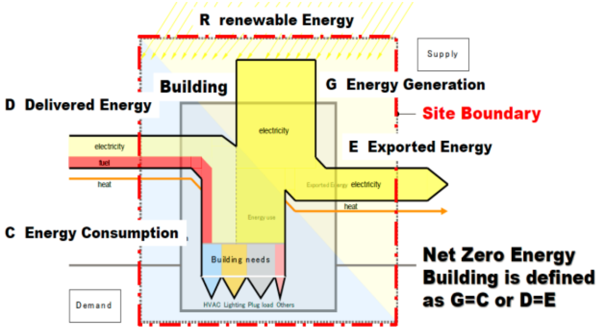

Figure 3-1-2

- **Boundary definition:** 1)Physical Boundary (ZEB energy balance is measured in the site boundary); 2)Accounting Balance Boundary (Targeted Energy Usage) (Figure 3-1-2)
- **Qualitative definition:** Quantitative Definition with boundary around building Energy Generation = Energy Consumption (G=C)
- **Net Energy Standard Measurement**, normalized consumption = normalized generation
- Classifications include ZEB ready, Nearly ZEB and Positive Energy (Figure 3-1-1)

3-2 Where to Draw Socio-Technical System Boundaries of Zero Carbon Buildings and Communities?

Dr Wei Pan, Department of Civil Engineering, University of Hong Kong

- Background of Zero Carbon Building in Hong Kong, China (buildings consume 92% electricity in Hong Kong, China, residential 26%, commercial 66%)
- 3 challenges for Zero Carbon Building development in Hong Kong, China: high rise, density, hot and humid climate, 7 million people
- Caveats: need to draw difference between energy and carbon
- Vision: To help position Hong Kong, China as a world-class knowledge-based, innovation-driven and multi-stakeholder-engaged hub for zero carbon building in urban environments.
- Hong Kong Zero Carbon Partnership to develop zero carbon buildings in urban environments solutions. Target: 100 organisational members; 5000 individual participants

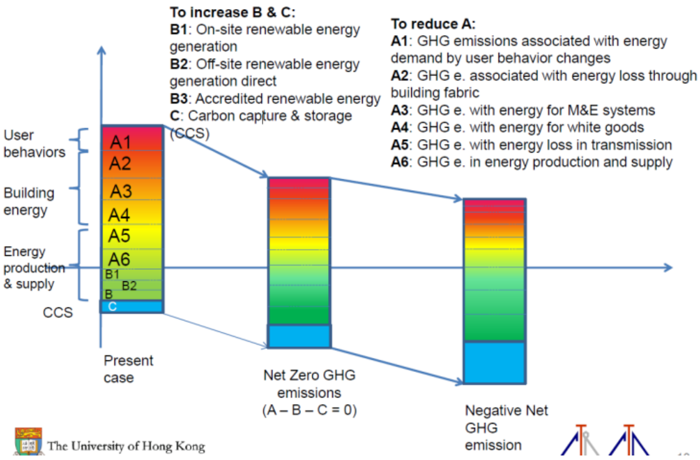

Figure3-2-1 Ten Elements of Zero Carbon Model

Seminar title	Participants
The principles of ZCB: within and beyond Hong Kong, China	All in the demand, supply, regulation and institution groups of ZCBs; with an international speaker: 150 participants
The practices of ZCB: good practices and lessons learnt	All, but focus on supply & demand groups; with an international speaker;150 participants
The policies of ZCB: international learning for Hong Kong, China	All, but focus on regulation & institution groups; with an international speaker;150 participants
The priorities of ZCB: addressing the challenges and maximizing the opportunities	All in the four groups; with an international keynote speaker; 150 participants

3-3 The Acceleration of Net Zero: How the Canadian Home Builders' Association is Supporting Industry Innovation

Sonja Winkelmann, Canadian Home Builders' Association

- Responsibility-- Pushing to support members' voluntary adoption of NZE
- Objectives-- technical standard, Track and measure success, program development
- Definition of NZE Home: A NZE home is one that is designed, modelled and constructed to produce as much energy as it consumes on an annual basis.
- NZE Ready = A NZE home that has not yet installed the renewables.
- PILOT Technical Specifications-- Key priorities for Year 1(NZE labelling Program, Marketing and Communication Initiative, Educational Initiative, and Financing Initiatives)
- Cost of NZE upgrade around $60K with some builders reporting cost-neutral achievement when considering energy savings.
- Labelling program BASE R2000+ERS 0 GJ + Energy Star requirements+ RE design evaluation & installation verification+ energy monitoring device with real time information for consumer
- Future Program Development:
- Fine tune NZE MURBs and NZE Renos - form Working Groups Fall 2015
- NZE Communities (District/Micro Energy & CHP) - form Working Group Fall 2015
- Top 10 "Must Have" Home Features:
- 1. Walk-in closets; 2. Energy efficient appliances; 3. Overall energy efficient home; 4. High-efficiency windows; 5. Kitchen islands; 6. Linen closets; 7. Open concept kitchens; 8. Large windows; 9. 2-car garage; 10. Walk-in pantry

3-4 Research on Performance Criteria of Nearly-Zero Energy Buildings in China

Dr *Shicong Zhang*, Institute of Building Environment and Energy, China Academy of Building Research

- Building Codes and Standards are the most fundamental and effective measure to promote NZEB development (according to APEC program conclusion).
- China building energy codes achieved 50-70% energy savings since 1970s, and still have 70-90% saving potential in the future.

- China Academy Building Research Nearly Zero Energy Building as a Pilot building July 2014 (50% cooling energy reduction in summer, no fossil fuel in winter)
- Need performance criteria of Passive Nearly-Zero Energy Building for China to enable certification
- Key points (Climate, Indoor Environment (increase indoor temperature as occupants find it acceptable), Behaviour, Building features, Energy use features)
- Did technical analysis to find best combination of design strategies to achieve nearly net-zero energy buildings in the different climate zones.

  Severe Cold Zone—improve building envelope, increase G value, no cooling need in summer

  Cold Zone-- improve building envelope

  Hot Summer Cold Winter—good shading, floor insulation, no heating need in winter

  Hot Summer Warm Winter Zone—Shading is important, plus floor insulation

Panel 4: Education for Net-Zero Energy: Challenges for Architecture and Engineering Programs

4-1 Educational Needs for Architects & Engineers to Consistently Create Smart Net-Zero Resilient Projects

Ann Edminster, Design AVEnues LLC, Pacifica, California, USA

- Designers' imperative: buildings and communities that are:
- Zero net energy (or better!), Resilient, Smart
- Getting to ZRS takes:
- 1. Explicit goals, set early along with priorities
- 2. Effective collaboration: Integrated Design + Delivery
- 3. A structured process: checking progress frequently
- 4. Quality management: throughout construction, high quality is not the industry standard
- Explicit goals set early along with priorities -- map to show you how to get there
- Education -- Must be not only a transmission of culture but also a provider of alternative views of the world and a strengthener of the will to explore them.

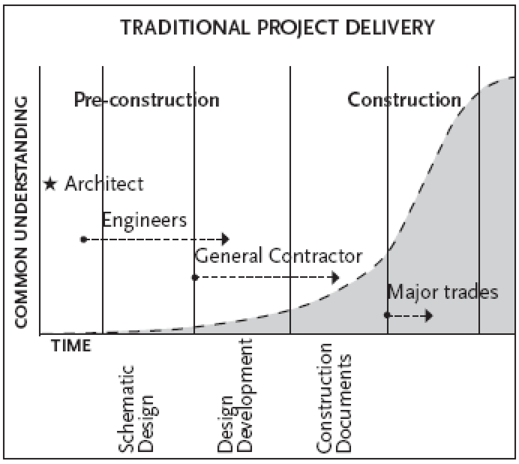

Figure 4-1-1 Business as usual

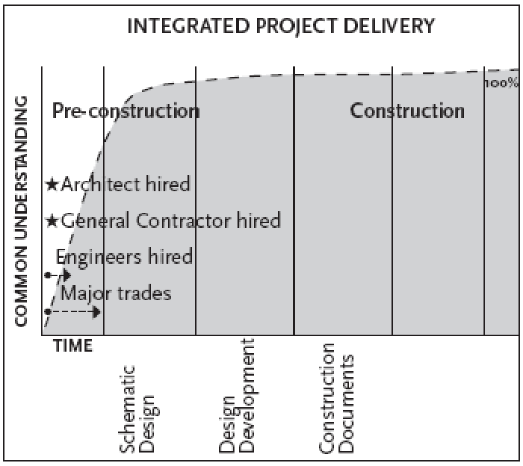

Figure 4-1-2 Integrated design & delivery

- Quality Management

4-2 When Environmental Evaluation meets Architecture Critique

Dr Carmela Cucuzzella, Design and Computation Arts Department, Concordia University, Canada

- Construct a design matrix of architectural expectations vs environmental strategies.
- Help architects see how the environmental goals can by met in synergy with architectural goals.

4-3 The Architecture Design Studio and High-Performance Building: Challenges and Reflections

Michael Jemtrud, School of Architecture, McGill University, Canada

- Overview of Architectural Design course and a Sustainable Design Course offered last school year
- Summary of teaching content- high-performance building principles and practices
- Building research Establishment Environmental Assessment Method (BREEAM) scheme can be used to evaluate sustainability in design as well as Passive House guidelines
- BREEAM Communities categories: 1. Governance, 2. Social and economic wellbeing, 3. Esources and energy, 4. Land use and ecology, 5. Transport and movement

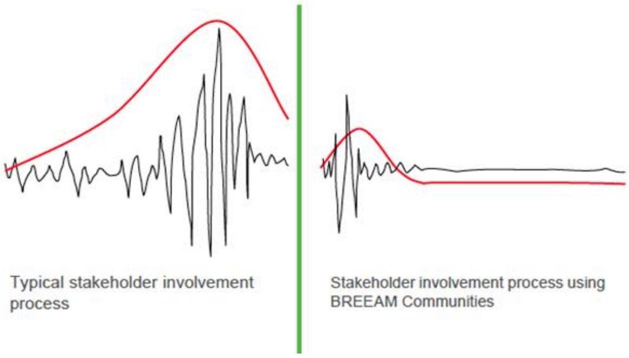

Figure 4-3-1 Strengthening stakeholder engagement

- Project-based interdisciplinary approach to show different pillars of sustainability
- Architectural Design --Tansey Development, Montréal, QC
- Sustainable Design -- Centre Magnetique, Lac-Mégantic, QC

Panel 5: Design of Net-Zero Resilient Communities

5-1 Context for Net-zero Resilient Communities

Chris Kennedy, University of Toronto

- Total investment needs for China's green building development in 2014-2020—520 billion Yuan
- The 3 parts of Infrastructure Sectors in Virtuous Cycle of Low Carbon Growth in China show strong interactions (Figure 5-1-1)

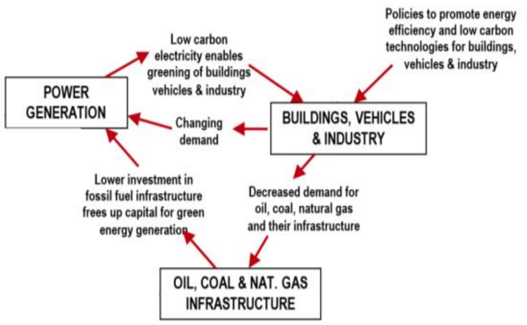

Figure 5-1-1

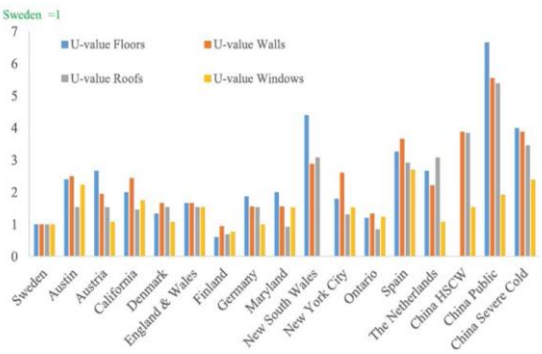

Figure 5-1-2

- Compare the different normalized value in various building codes with U-values for floors, roofs, walls and windows.
- Compare different low carbon infrastructure strategies for various cities (Figure 5-1-3)

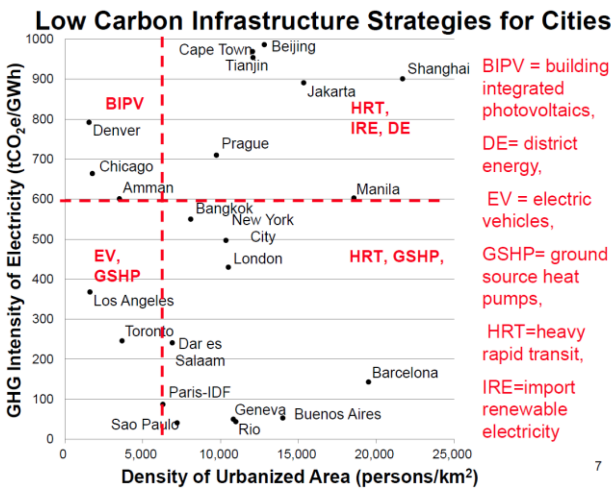

Figure 5-1-3

5-2 Towards resilient cities: Canadian initiatives

Dr *Caroline Hachem-Vermette*, Faculty of Environmental Design, University of Calgary, Canada

- Design of neighbourhoods should be considered as holistic ecosystems
- Current community design process in industry not conducive to optimal energy management and sustainability
- A number of initiatives are underway to look at optimising solar potential of communities

5-3 Net-Zero Resilient Communities: Three Canadian Case-Studies

Dr *Scott Bucking*, Department of Civil and Environmental Engineering, Carleton University, Canada

- Optimisation study of annualized net-present value of buildings found to be at around 50 kWh/m2
- Three case studies presented: West 5 Community in London, Zibi Community in Ottawa, Burlington Innovation District at McMaster University
- Case 1: Zibi Community, Ottawa, ON, 40 acres; NZCarbon; http://zibi.ca
- Energy Modelling Report
- Case 2: West 5, London, Ontario, 70 acres, 2000 living units, 100,000 ft2 offices, 150,000 ft2 retail
- Smart energy plan is design for economic development, micro- grid with CHP
-
- At community scale, it is not clear where to invest limited money, on individual buildings, or on community energy systems, use BID Simulated Performance (Figure 5-3-1)

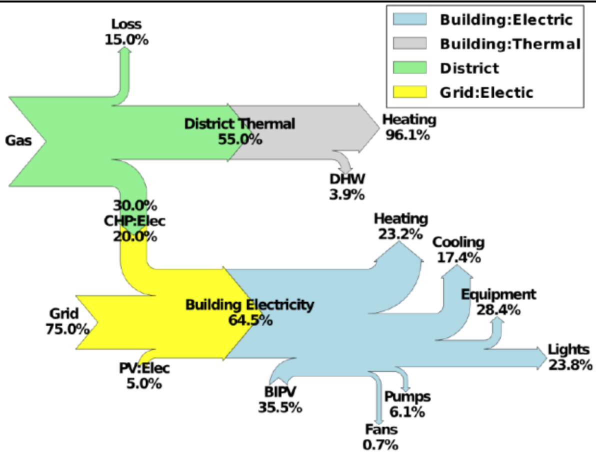
Building:Electric
Building:Thermal
District
Grid:Electic
Loss
15.0%
Gas
District Thermal
55.0%
Heating
96.1%
DHW
3.9%
30.0%
CHP:Elec
20.0%
Heating
23.2%
Cooling
17.4%
Equipment
28.4%
Grid
75.0%
Building Electricity
64.5%
Lights
23.8%
PV:Elec
5.0%
BIPV
35.5%
Pumps
6.1%
Fans
0.7%

Figure 5-3-1

Panel 6: Building Integrated Solar as an Enabling Technology for Net-Zero Energy and Resilience

6-1 Building Integrated Solar Thermal Systems: Technology Appraisal

Dr *Soteris Kalogirou*, Department of Mechanical Engineering and Materials Science and Engineering, Cyprus University of Technology

- COST Action TU1205 (2013-2017) did survey of building integrated solar thermal systems (BISTS)
- Many examples of solar thermal collectors used as balustrades in balconies (especially in China)
- Transpired solar collector (SOLARWALL) used in many applications
- Many commercial technologies exist, and the TU1205 will explore developing different types of BISTS technologies. www.tu1205-bists.eu

6-2 Building Integrated PV-thermal collectors and systems

Dr *Christophe Ménézo*, Chair INSA-EDF/Fédération sur l'Energie Solaire - FédEsol FR 3344/USMB, France

- PV/T development has been going on for more than 35 years.
- Three air based prototypes developed (pleated double-skin façade, veranda/rooftop, façade/rooftop) that could be used in retrofit applications, and a liquid type PV/T collector developed
- Water type collectors still have issues with aging, stagnation, reliability. Air systems are being used in more cases.
- PV/T makes it easier to develop net-zero and net-positive energy buildings.

6-3 Assessment of Roof Capacity for Active Solar Energy Generation in Housing Developments

Esteban Zalamea, Department of Design and Theory of Architecture, University of Bío Bío, Chile

- Large amount of housing being built, wanted to study potential of solar energy generation from roofs. Potential generation of 19789 MWh/year for 3132 houses

- Single pane windows and minimal insulation used in houses in Chile leads to a large heating demand. With increased insulation and PV/T on roof can lead to significant over production that could be used to supply neighbouring houses.

6-4 BIPV/T + ASHP: Technologies for Near and Net-Zero Energy Buildings

Dr *Alan Fung*, Department of Mechanical and Industrial Engineering, Ryerson University, Canada

- Residential sector in Canada consumes energy mostly for space heating (63%) and domestic hot water (17%).
- PV costs are approaching grid parity. Building integration and thermal energy usage will further decrease energy generation costs.
- PVs only convert 12 to18% from solar to electricity.
- Proper utilisation of low-grade thermal energy of PV/T systems is a challenge. Coupling with cold climate air-source heat pump offers good promise.
- Test hut being built in full-scale (30 ft *25 ft) to develop a PV/T system with heat pump and ventilated gravel/concrete bed and PBC-water storage tank.
- 3 main systems of the test facilities:
- Building Integrated Photovoltaic/Thermal collector (BIPV/T) system
- Integrated Heat Pump (HP) system
- Thermal Energy Storage (TES) system including ICF Wall, Ventilated Concrete Slab, Gravel/Sand bed, and PCM-Water Tank storage
- 3 major parts included in the test hut as thermal energy storage:
- Ventilated Sand / Gravel Bed
- Ventilated Concrete Slab (VCS).
- Insulated Concrete Form (ICF) Wall
- Need to develop standardized way to integrate PV to houses.

6-5 Modelling PCM, BIPV/T and other innovative technologies for energy efficiency in buildings: a case study

Dr *Annamaria Buonomano*, Department of Industrial Engineering , University of Naples Federico II, Italy

- Building case study in Naples, Italy. Non residential, includes office spaces, conference area, etc.
- Parametric building simulation done to minimize energy consumption evaluating many different parameters.
- Excess thermal energy generation to be supplied to a neighbouring building
- Of the number of technologies studied, PCM was not found to have savings that justified the costs.

Panel 7: Energy Efficiency Technologies and their Integration with Renewables

7-1 Design of resilient and robust high-rise residential buildings

Dr *Liam (William) O'Brien*, Department of Civil and Environmental Engineering, Carleton University, Canada

- 50% more high-rise units housing starts compared to single detached, but lack of research into this building type, despite the many unique challenges in this sector (Thermal bridging, Overheating, Extreme radiant temperatures, Single-sided (only) natural ventilation, Cold floors near balconies, Limited renewable energy collecting surfaces) (Figure 7-1-1).

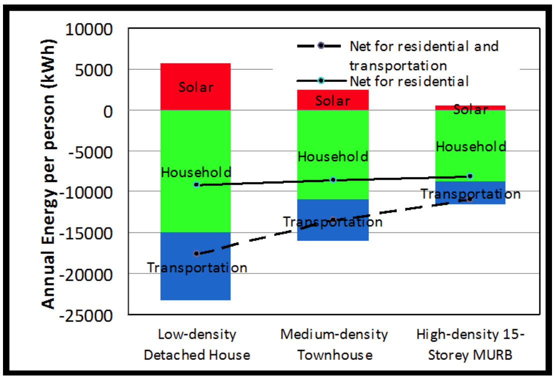

Figure 7-1-1

- New condo field study--20 participants in condominiums built in the past 10 years to find the comfort impact (Thermal comfort, adaptive behaviours, interior conditions like window size and billing type)
- Study found that people that pay for their heating keep their setpoint on average at 20.1ºC vs 21.9ºC for bulk metered units.
- Thermal bridging is important to consider in modelling high rise buildings
- In terms of resilience occupant interactions can be as important as design elements.

7-2 The development of mPCM enhanced tile for high performance buildings

Dr *Umberto Berardi*, Faculty of Engineering and Architectural Science, Ryerson University, Canada

- With high number of highly-glazed high rise buildings built in last decade, integrating additional thermal mass would help address some comfort issue. Passive PCM-material would be good option to provide high thermal storage potential in low surface area.
- Many of PCM projects done in Canada have focused on lab project, lack of research in real project applications.
- Adding paraffin to concrete can increase its heat storage capacity by 2-3 times without impacting its structural strength too much.
- Paraffin embedded concrete tiles first used in Solar Decathlon house now a commercial product, and are working with a ceramic tile manufacturer in Italy to do the same

7-3 High performance building envelopes for Smart net-zero resilient buildings

Dr *Hua Ge*, CZEBS, Concordia University, Canada

- For all new building envelope technologies, it is important to ensure the integrity of the building envelope, which can reduce 70% heating loads (Figure 7-3-1)

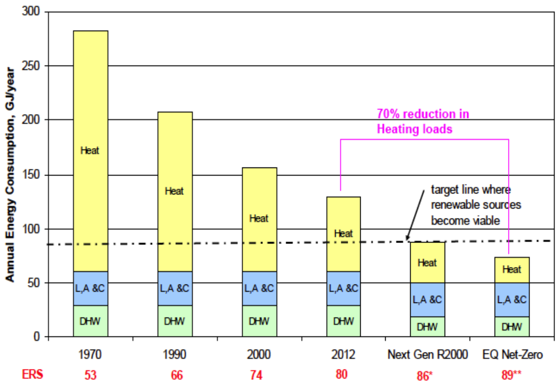

Figure 7-3-1

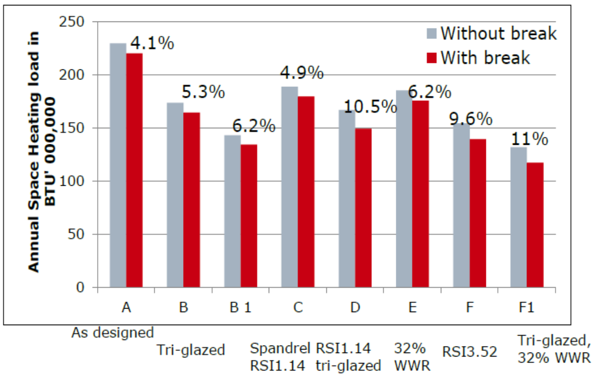

Figure 7-3-2

- Need durability. HAM analysis is important.
- Innovative insulation materials: VIP, VIM, aerogel, nano-insulation materials (NIM), PCM, Transparent Insulation materials (TIM)
- Advanced glazing/windows: VIG, evacuated aerogel glazing, PCM windows, TC, EC, PV integrated EC, SPD, gaschromic, dynamic IR coating, etc.

- Hygrothermal analysis done on CLT wood panels, and highly insulated wall assemblies.
- Durability analysis shows that durability risks tend to be reduced due to the increase of temperature, solar radiation
- BIPV/T +Attic, Ventilated v.s. unventilated
- Thermal bridging affect annual space heating load (Figure 7-3-2)
- A number of uncertainties in material properties, assumptions on air and water leakage, and modelling need to be examined to ensure that results are realistic.

7-4 Wind Energy Potential of Urban Areas

Dr *Ted (Theodore) Stathopoulos*, CZEBS, Concordia University, Canada

- Wind speed lower and turbulence higher in urban environments, need to maximize power output at low wind speed.
- Proper selection of turbine location will greatly impact performance, need to model the wind speeds over different areas of the roof.
- Need a method to determine wind speed at urban location from existing wind monitoring stations.
- Wind tunnel methodology tested against field monitoring and found to be in good agreement (within 5%) in homogenous terrain, but only within 30% for non-homogenous terrain.

7-5 Performance analysis of GSHP system in CABR nearly zero energy buildings (NZEB)

Dr *Huai Li*, Institute of Building Environment & Energy, China Academy of Building Research

- Two ground-source heat pumps, one for radiant floor (2nd) and radiant ceiling (3rd) and one for air based system on ground level.
- 79 boreholes with single U, double-U and spiral tubes.
- COP of radiant unit started at 5.4 at beginning of winter and went to 4.8 after three months, compared to 4.7 and 3.9 for COP of air based unit
- Over the entire year, soil temperatures were seen to recover in summer after winter such that temperatures at the beginning of winter remained similar.

Panel 8: Optimizing Building Operation, Storage and Grid Interaction

8-1 Heat Pump Water Heating Control Strategy Optimization for Cold Climates

Dr *Cynthia Cruickshank*, Department of Mechanical and Aerospace Engineering, Carleton University, Canada

- Effective 2015 tanks larger than 55 US Gal will be required to use heat pump water heaters in US
- HPWH studied at CCHT found no significant change of total house energy use in winter as 1/3 DHW savings was counter balanced by 6% increase in space heating. Benefits found in summer.
- Used experimental setup to validate TRNSYS model and GenOPT to optimise design/control of 10 different parameters.
- HPWH cost effectiveness varies according to utility rates, and heating fuel type.

8-2 Energy storage will enable net-zero energy buildings to become mainstream

Dr *Lukas Swan*, Department of Mechanical Engineering, Dalhousie University, Canada

- Posits that electricity storage required for mainstreaming of NZEB
- As penetration of PV increases, grid will no longer be able to cope with fluctuations in generation
- Proponent of electric storage as a buffer, but not to use the storage to lead to off-grid houses.
- Need to bring research groups together (storage, ZEB and smart grid)

8-3 Modelling and Design of Natural and Hybrid Ventilation Systems for High Performance Buildings

Dr *Leon (Liangzhu) Wang*, CZEBS, Concordia University, Canada

- Need systematic/integrated approach to consider natural ventilation in design. Tools for early stage concept and late stage, and for managers vs engineers
- Developed and presented early stage tool with simple inputs and outputs to evaluate the potential of natural ventilation.
- Detailed modelled developed to be validated with experimental work at Concordia EV building atrium

8-4 Advanced Control of Heat Pumps and the Impact on Building/Grid Interactions

Justin Tamasauskas, Natural Resources Canada, CanmetENERGY-Varennes

- Heat pumps provide link between thermal and electrical networks
- Evolution of buildings requires new approach to control (model predictive control)
- Predictive control tested with TRNSYS model coupled to MATLAB model.
- Predictive control allows the space heating energy consumption to be spread out over the day making it a good peak management tool.

Conclusion

After the 2-days Symposium, the four plenary speakers and from 3 to 5 speakers on eight different Panels discussing a range of topics from individual technologies, to communities and their interaction with the grid and policies, standards, incentives and education needed to accelerate the adoption of net-zero energy buildings. 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 on NZEB development, together with relative policies, standards, and incentive measures.
4. Education for Net-Zero Energy Building design and construction has been launched in many developed economies, such as Canada, the U.S.
5. Optimizing building operation monitoring is critical in further development

Appendix V

Meeting notes of 2nd workshop

(Taichung City, Chinese Taipei)

APEC Workshop Nearly/Net Zero Energy Building --

From Best Practices to Mass Market

工業技術研究院
Industrial Technology Research Institute

中国建筑科学研究院
China Academy of Building Research

APEC Workshop
Nearly/Net Zero Energy Building -- From Best Practices to Mass Market
Meeting Notes

2nd workshop of

APEC Nearly (Net) Zero Energy Building Best Practices and Energy Reduction Comparative Study project

EWG 02 / 2015A

11th April 2016

The Splendor Hotel Taichung

Taichung City, Chinese Taipei

Nearly/Net Zero Energy Building -- From Best Practices to Mass Market

Monday, April 11, 10.30-12.00
The Splendor Hotel Taichung, Taichung City, Chinese Taipei

Workshop organiser

Shicong Zhang http://www.cabr.com.cn/

Goal of this workshop

- Enhance mutual understanding of economy's latest NZEB progress. e.g. How many pilot projects (best practices) are there and what is the growing trend? What kind of technologies were used? Is there any financial incentives or subsidies?
- Exchanging each economy's learning and experiences from the best practices. e.g. what is the energy consumption of the pilot projects compared with the average baseline? Did the pilot building runs as simulation? Did the advanced technology used in the building works as it should be?
- Discussion of the barriers and obstacles for the APEC NZEB best practices information collection, find the solution for the information collection in the next step.
- Discuss of how to enlarge the influence of best practices and move to mass-market.
- Discuss of the potential possibility to prepare APEC Nearly/Net Zero Energy Building Roadmap.

Presenter

Dr Bruno Lee

Concordia Centre for Zero Energy Building Studies (CZEBS), Canada

Dr Wei Feng

Lawrence Berkeley National Laboratory, USA

Dr WU Jianlin

China Academy of Building Research, China

Prof Dongwoo Cho

Korea Institute of Civil Engineering and Building technology

Prof Gyu young Yoon

Nagoya City University, Japan

Dr Usha Iyer-Raniga

School of Property, Construction and Project Management, RMIT University

Dr Ming-Shan Jeng

Division Director of Intelligent Energy-Saving System in GEL/ITRI, Chinese Taipei

Dr Margaret KAM

Construction Industry Council - Zero Carbon Building. Hong Kong, China

Workshop organiser

Date / Time	Session	Speaker
0800-0840	Workshop Registration	
0840-0850	Welcome	
0850-0900	APEC NZEB Program Introduction and overview	
SECTION I Latest Progress and Overview Chair: Dr Usha Iyer-Raniga		
0900-1030	From residential to commercial NZEB, best practices in Canada	Dr Bruno Lee NSERC Smart Net-zero Energy Buildings Strategic Research (SNEBRN) Concordia Centre for Zero Energy Building Studies (CZEBS), Canada
	The Recent Development of Net Zero Energy Buildings in the United States	Dr Wei Feng Lawrence Berkeley National Laboratory, USA
	From Best Practice to Mass Market : Latest Progress of NZEB in China	Dr WU Jianlin China Academy of Building Research, China
	Policies and Best practices toward nZEB in Korea	Prof Dongwoo Cho Head, Senior Research Fellow, Ph.D National Green Building Center Korea Institute of Civil Engineering and Building technology
1030-1045	Group Photo and Tea Break	
SECTION II Best practices & Case Study Chair: Dr Margaret KAM		
1045-1215	Policies and Best practices toward nZEB in Japan	Prof Gyu young Yoon Nagoya City University, Japan
	Post occupancy evaluations of ZEB and ZCB in Australia	Dr Usha Iyer-Raniga B. Arch., M.A.S.A., PhD Associate Professor Deputy Head, International Researcher, Sustainable Building Innovation Lab (SBiLab) School of Property, Construction and Project Management, RMIT University
	Zero Energy Building Technology Alliance (ZEBTA) of Chinese Taipei	Dr Ming-Shan Jeng Division Director of Intelligent Energy-Saving System in GEL/ITRI, Chinese Taipei
	Towards Zero Carbon: Experiences and Future Directions of Hong Kong, China's First Zero Carbon Building	Dr Margaret KAM, Assistant Manager - Technical Services, Construction Industry Council - Zero Carbon Building. Hong Kong, China

1215-1230	Discussion and Wrap-up

Key Points from Presentations

【Opening】APEC nearly(Net) Zero Energy Building Program

Zhang Shicong China Academy of Building Research

- **APEC Program Background** is introduced, and some results and achievements is presented with APEC members: APEC report has been downloaded 2546 times.

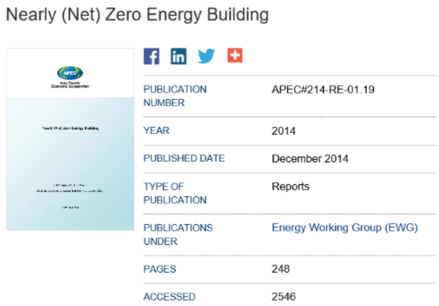

Figure 1

- **Objective of the program is summarized:** Exchanging information and experience, compare difference and similar; promote finding and outcomes, push market development and set up related association and alliances.
- **Progress of Best practices in China is shared,** including projects, best practices time schedules and finished workshops, attended meetings
- **Next Step:** 2nd meeting notes, Best Practices analysis and final program report, and New APEC proposal et, al.

01 From Residential to Commercial NZEB, Best Practices in Canada

Dr Bruno Lee

This presentation focus on Project introduction;

- **EcoTerraTM Equilibrium House,** passive technologies utilized in this project, PV panel, GSHP, high performance envelop and windows; shadings,
- Energy consumption in different sections are analyzed;
- Compare two study projects, one with BIPV and the other with BIPV/T. Thermal heating almost the same as solar electricity, challenges of implementing a BIPV/T system is to make effective use of energy from the heated air.
- Building Integration of PV is introduced;

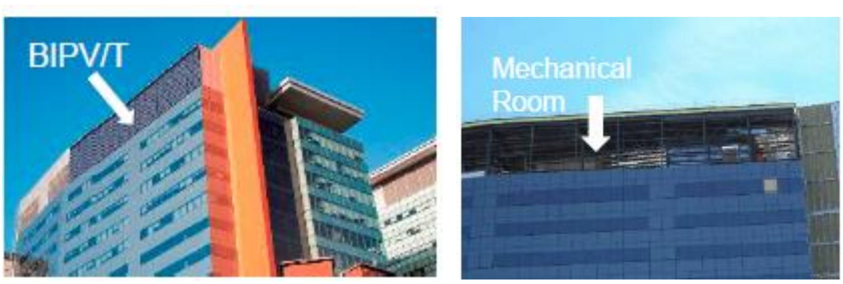

Figure 2

- Development and Optimization of BIPV/T system is analyzed.
- **Varennes NZEB Library design,** Hybrid Vehicle, BIPV, light Shelves, Automated Operable Windows;

Figure 3

- **Yearly Energy Consumption per Area** is analyzed, energy production by PV

panel is about 87% of total energy consumption of this building;

This presentation described NZEB development in Canada by two projects, and passive technologies, renewable energy such as BIPV is introduced mainly, its performance in the projects, yearly energy consumption are shown and analyzed in detail.

02 Recent Development of Net Zero Energy Buildings in the U.S.

Wei Feng, Ph.D, Lawrence Berkeley National Laboratory

- **New Policies and development of Net Zero Energy(NZE) buildings:**
  - There are 3339 projects totally in U.S. large number projects become net zero or ultra low energy buildings (Commercial), ZNB use only 25% energy than average buildings in the U.S. Schools, public buildings, and office are common types;
  - Zero energy buildings definition: Zero Net Energy(ZNE) Buildings, Zero Energy Campus, Zero Energy portfolio, Zero Energy Community;
  - DOE Zero Energy Ready Home Webinars; on line trainings , 6 core values;
  - Passive Houses in the U.S. Re-evaluated German standards, and adaptions were developed;
  - Living Building Challenge, the first labeling program to certify net zero energy and water buildings, Certify actual measured performance, not just design performance.
  - California's Zero Net Energy plan update,
- **Two case studies**

  An Office Building in CA, net positive performance for a whole year, and measured energy consumption is lower than modeled one. Daylighting/skylight, co-exist with PV, Natural ventilation with ceiling fans; LED lighting;

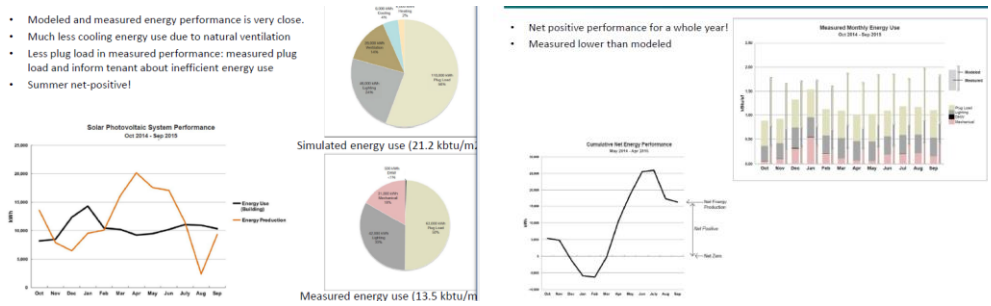

Figure 4

An office building Colorado, technologies in use: Daylighting, skylight, co-exist with PV, natural ventilation with ceiling fans, LED lightings et.al. well insulated envelop, seal all gaps for air tightness;

- **U.S. case collection**

➢ 10 cases are shared, distributed in different positon of U.S., including Laboratories, interpretive center, higher education school, campus, Libraries. All these cases are net zero energy building.

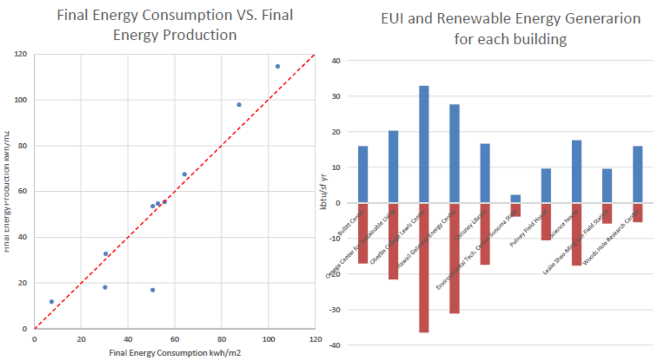

Figure 5

➢ Experience learned from cases in the U.S.: Comprehensive policies to support NZE development, and its development is still in early development, stages, Energy efficiency to reduce energy demand and make buildings net zero energy ready, most cases show that technologies are ready to develop net zero energy buildings, living energy data and dashboard to provide real-time performance feedback.

03 Best Practice of Net(Nearly) Energy Buildings(nZEBs) in China-From pilot to Mass Market

Jianlin Wu, Institute of Building Environment and Energy, China Academy of Building Research

➢ **Background of NZEB development in China,**

- **Changes** internationally, capping of carbon emission, challenge of building sector, indoor comfort;

➢ **Pilot projects: More than 20 pilot projects in China,** including residential houses, commercial buildings and schools around China;

Figure 6

CABR NZEB, with real-data evaluation, and it is the first nearly zero energy public building in China, the target energy consumption is 25kWh/(m^2y), and two year operation data is 23kWh/(m^2y). It is facilitating strong growth of NZEBs in China and laying foundation for future development of China's NZEB standard.

➢ Pilot projects: office type dominated, 54.55%, residential 18.18%, &2.73% of the pilot projects lie in heating dominant region, 22.73% in heating and cooling balanced region.

- Sun shading, natural ventilation are dominated passive technologies and radiant heating and cooling are main active technologies utilized in pilot projects.
- Shandong, Hebei, Beijing and some other province local government has carried relative policies to promote development of ZEBs;
- Issuing of 《Technical guidance on Passive green residential house of China》 in November 2015;

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

Figure 7

- Mass market :China Passive Building Alliance is founded, more than 200 enterprises ,design firms form the alliance, it will provide technical and product support for NZEB design, construction commissioning and certification;
- Target

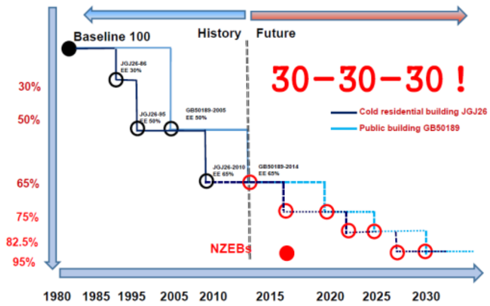

Figure 8

04 Policies and Best Practices toward Nearly/Net Zero Energy Building in Korea

Dongwoo Cho, Senior Research Fellow, Korea Institute of Civil Engineering & Building Technology, Korea

- **Policy of zero energy building in Korea**

In this section, Policy of zero energy building in Korea is introduced generally,

① Definition and Certification System of zero energy building;

②. Policy for promotion of zero energy building;

③. Strategies for promotion of zero energy building;

- ➢ Low-rise pioneer zero energy building projects
- ➢ High-rise pioneer zero energy building projects
- ➢ Pioneer zero energy town
- ➢ 3 supportive measures to reduce additional construction cost

- **4 Best practices of zero energy buildings are introduced;**

They are: Sampyeong Post Office, National Institute of Environmental Research, Seoul Energy Dream Center and Zero Carbon Green Home;

Figure9 Practices of nZEB in Korea

- **Summary**

Policy of aero energy building, fist makes a clear definition of zero energy building that is the green building that is minimized building load and energy requirement by supply of new & renewable energy. Then from Policy, Strategy and Measures three aspects introduced promotion of zero energy building. Strategies for promotion of zero energy building's main mission are developing pioneer zero energy building projects with a new approach and creating from best practices to mass market, mainly including three parts: Low-rise, High-rise pioneer zero energy building projects and Pioneer zero energy town. As to Measures for promotion of zero energy building, 3 supportive measures are ongoing in order to reduce additional construction cost.

Next it takes Sampyeong Post Office, National Institute of Environmental Research, Seoul Energy Dream Center and Zero Carbon Green Home for examples, describes the part of best practices of zero energy building in detail.

Finally, considering the situation in this area, the power point points out the barriers, including Incremental cost for passive approach and renewable energy system, Relatively lower energy cost and so on, and points out how to promote nearly/net zero energy building development together.

05 Polices and Best Practices towards nZEB in Japan

Gyuyoung Yoon, Nagoya City University, Japan

- **Best practices**

In this section, fashionable passive &active measures in nearly zero energy building in Japan is introduced. The measures are:

①fashionable passive measures: Natural ventilation, night purge; solar shading devices; daylight utilization; exhaust air and reuse; perimeter buffer system; others.

② fashionable active measures: separate sensible & latent heat HVAC system; radiation H/C system lighting/HVAC system; task &ambient/HVAC system; LED lighting; fresh air volume control by CO_2 concentration; large temperature difference water supply; high efficiency heat pump module chiller; ground heat source heat pump; desiccant HVAC system; tes, energy management, visualization and others

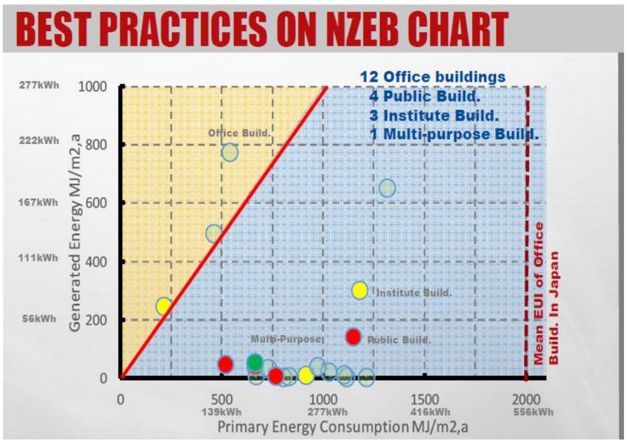

Figure 10. Best practices on NZEB chart

- In addition, measures for system efficiency are applications of high performance equipment and high performance HVAC system; the most popular renewable sources in the cases were showing is PV.

- **Challenges to promote NZEB**

Some barriers in development of NZEB in Japan is still ahead, works and challengers to promote NZEB is

1. Definition of NZEB need to be clearly identified from narrow and broad sense.
2. Lack of design know-how: no established design procedures for integrating of each energy saving measures; sharing of know-how is difficult, because of diversity of NZEB design; not enough of case study for estimation of cost performances of NZEB design.
3. Additional cost become a burden of owners; gap of benefit caused by NZEB between owners and tenants.

- **Summary**

This presentation discusses Polices and Best Practices towards nZEB in Japan. Firstly, It introduces contents of best practices and best practices on NZEB chart. Then the writer gives some details about fashionable passive &active measures, such as fashionable passive measures including natural ventilation, night purge and solar shading devices, etc. and fashionable active measures including separate sensible & latent heat HVAC system, radiation H/C system lighting/HVAC system etc. As summary, it shows some technology outlines about NZEB. Secondly, the writer pays attention to the Challenges to promote NZEB. There are many difficulties to promote NZEB, such as lack of design know-how. There are no established design procedures for integrating of each energy saving measures, so sharing of know-how is difficult because of diversity of NZEB design and there are not enough of case study for estimation of cost performances of NZEB design. But the attractive of NZEB is promising.

06 Zero energy and post occupancy evaluation

Associate Professor Usha Iyer-Raniga, School of Property, Construction and project Management

- **Definitions of nearly zero energy building is introduced from different viewpoints.**
  - ➢ Zero/Net Zero
  - ➢ Energy: net zero sources energy building; net zero site energy building.
  - ➢ Cost: net zero energy cost.
  - ➢ Emissions: net zero energy emissions.
  - ➢ Comparison between Australia and other countries is introduced.
- **Instruction of development in Australia.**
  - ➢ Australia's targets: ①Goal is to reduce emissions to 26-28% on2005 levels by 2030.② Abatement task estimated at 1.3 billion tones in 2008, has now reduced to 236 million tones on emission reductions.
  - ➢ How does Australia fare compared to other countries?; AUSTRALIA is responsible for 1.3% of global emissions.
  - ➢ How can Australia achieve its targets?
  - ➢ Australian context of energy use in buildings: ① Energy use of buildings contributes to 20% of national greenhouse gas emissions; ② Heating and cooling 11% of national greenhouse gas emissions; ③ Typically: Space heating and cooling: 41% and Domestic water heating: 30%.
  - ➢ Life cycle energy

- **Case study:**

Lochiel Park & Josh's House

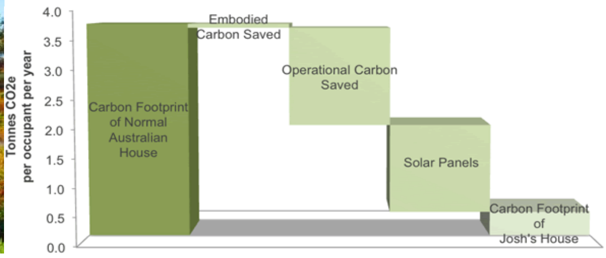

Figure 11

Case Study of POE

- ➢ Benefits and challenges of POE
- ➢ Hong Kong, China: To generate understanding of thermal comfort, air cleanliness and noise towards occupants' performance. India: Investigation on sensation and preferences for other environmental parameters of occupants.
- ➢ The urban learning lab, Learning from SAB
  - Research Aim: The aim was to understand the challenges, opportunities and lessons learned from the process of building a best practice green building at an Australian university.
  - Methodology: The case study was undertaken using a mixed method approach.
  - Findings
  - Conclusion and Challenges

Summary

This presentation is made by RMIT, Professor Usha Iyer-Raniga. The main topic is "zero energy and post occupancy evaluation". First, it gives some Definitions. And then it starts to introduce situation in Austria, such as Australia's targets, how Australia fares compared to other countries and so on. It describes the cases of Lochia Park and Josh's House in the form of a chart. Next is to introduce another important content that is post occupancy evaluation (POF), including definitions, benefits, challenges and barriers of POE. Then it take POE in Hong Kong, China and Indian for examples, Third main part of this PowerPoint are explain the background of why they should pay attention to Zero energy and post occupancy evaluation .They also bring forward their Research Aim and Methodology. Finally, they come to some conclusion and challenges.

07 Zero Energy Building Technology Alliance (ZEBTA) of Chinese Taipei

Dr Ming-Shan Jeng, Green Energy & Environment Research Laboratories, Industrial Technology Research Institute

- **Zero Energy Building Technology Alliance (ZEBTA) of Chinese Taipei**
  - Zero Energy Building Technology Alliance: ①In 2011, MOEA and ITRI co-launched the ZEBTA (Zero Energy Building Technology Alliance);② More than 100 leading companies joined the alliance.

Figure 12

  - Scope of Member Companies: ①design and structure; ②energy saving; ③renewable energy; ④intelligent energy & control.
  - ZEBTA's Missions and Activities: ①raising public awareness of zero energy building; ②platform for information exchange and networking; ③ZEB technology advancement.
- **A ZEB example – the Cafeteria in ITRI Central Campus**
  - Project Overview: located in Nantou; Cafeteria total area: 792.65 m^2, Conditioned area: 704.34 m2 (dining room + kitchen), Gross roof area: 804.33m^2
  - Technologies Used in the Underground Geo-Cooling Project: ①High performance design; ②Natural Ventilation; ③underground Geo-cooling;④ Zonal Air-conditioning; ⑤High Efficiency Lighting.
  - Achieving Net-Zero: Saving up to 52% comparing to the baseline design was realized; 45.57kWp PV is enough to cover overall annual energy consumption.
- **Conclusions:** ①A test-bed of ZEB for ITRI and industrial partners from ZEBTA was realized in the zero-energy cafeteria project; ②Through the integration of active and passive approaches, 52% of the baseline energy consumption was conserved and the rest was fully covered by PV to accomplish the goal of net-zero energy; ③US $27.4 thousand is the engineering cost for enhancing energy savings in this project and ROI is 11.4 years based on the electricity fee of Chinese Taipei with ongoing verification of measurement; ④Even though all the individual technologies have been seen before, the innovation in this project is how they are seamlessly integrated at competitive cost; ⑤Long term and clear policy is needed to drive the adoption of NZEB in Chinese Taipei; ⑥More international collaborations is necessary for promoting and testing of various "best practices" in different

climate zone.

- **Summary**

ZEBTA was co-launched by MOEA and ITRI together in 2011. More than 100 leading companies joined the alliance, in an effort to boost ZEB technology development and create new business opportunities. Member companies' scope includes design & structure, energy saving, renewable energy and intelligent management &control. ZEBTA's Missions and Activities consist of raising public awareness of Zero Energy Building, Platform for information exchange and networking and ZEB technology Advancement. The typical case is the Cafeteria in ITRI Central Campus, it locates in Nantou, Cafeteria total area: 792.65 m2, Conditioned area: 704.34 m2 and Gross roof area: 804.33 m2. Technologies such as High Performance Design, Natural Ventilation,

Underground Geo-cooling, Zonal Air-conditioning, High Efficiency Lighting are used in this building. The good news is that the building Saves up to 52% comparing to the baseline design was realized and 45.57kWp PV is enough to cover overall annual energy.

From this success case, many conclusions can be got, such as A test-bed of ZEB for ITRI and industrial partners from ZEBTA was realized in the zero-energy cafeteria project, through the integration of active and passive approaches, 52% of the baseline energy consumption was conserved and the rest was fully covered by PV to accomplish the goal of net-zero energy and so on. However, long term and clear policy is needed to drive the adoption of NZEB in Chinese Taipei and More international collaborations is necessary for promoting and testing of various "best practices" in different climate zone.

08 Towards Zero Carbon – Experiences and Future Directions for Hong Kong, China's First Zero Carbon Building

Dr Margaret Kam, Construction Industry Council

- **Hong Kong, China's Carbon Reduction Target**

① Hong Kong, China's government aims to reduce carbon intensity by 50-60% by 2020 as compared with 2005 level

② Potential measures to realize the target are introduced.

- **HongKong's First Zero Carbon Building is introduced.**

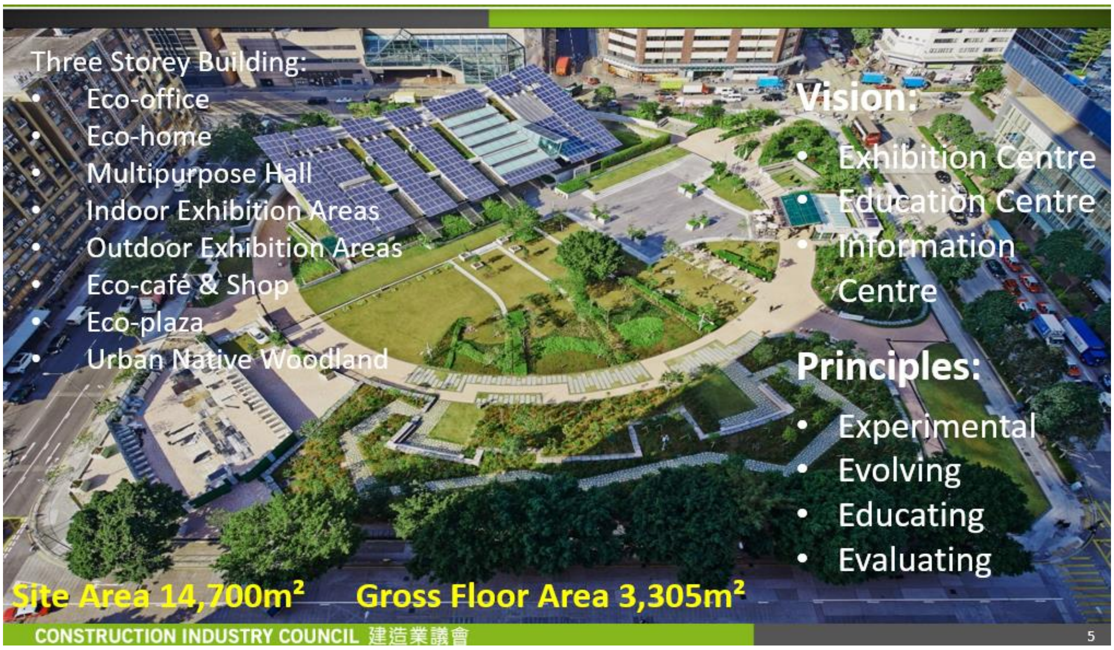

Figure11 HongKong's First Zero Carbon Building

①**Passive Design Measures:** Orientation for solar access; ventilation and daylighting; High performance glazing and external fins for solar control and shading; Sustainable site design; Open plan for cross ventilation; Orientation and façade design to maximize natural daylighting; Light shelves to optimize daylighting.

- Landscaping, Low Carbon Materials , Active Systems , Renewable Energy Generation measures are introduced.

②**Overall Strategy**

Energy Usage and Data Collection: Over 2800 sensors and Building Management System for monitoring and data collection for evaluating building performance

Real Time Performance Display: through the Building Environmental Performance Assessment Dashboard

Real operation data of energy consumption in year 2013,2014 and 2015 are introduce and compared by month and sections, and performance gaps attributed to: Increased building Usage; Energy consumed outside of normal working hours ; Energy consumption related to nonessential services. Carbon footprint is also analyzed.

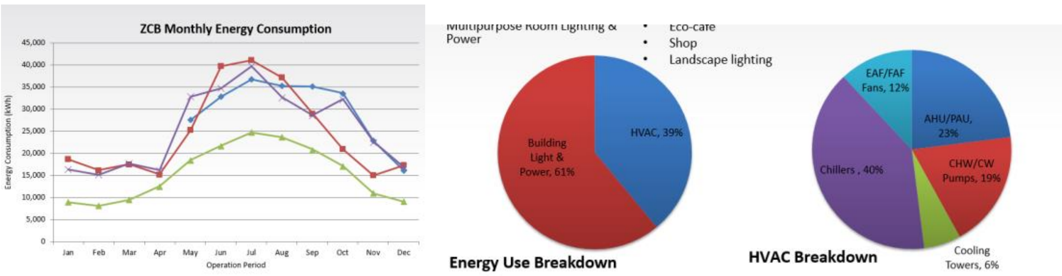

Figure12 Yearly energy consumption of zero carbon building

③**Challenges to Achieving Zero Carbon:** Differences in designed and actual operational and commercial use; extended testing and commissioning; balancing zero energy with occupant behavior, comfort, control and satisfaction; Facilities management practices

- **Summary**

This PowerPoint describes Hong Kong, China's First Zero Carbon Building' (ZCB) situation in detail. From Hong Kong, China's Carbon Reduction Target to ZCB's Carbon, Energy Strategy. Next, it introduces passive design measures used in the construction process. Apart from these, some other advanced technologies that has been adopt also has a clear presentation.

In the end, it answers the questions "What are the gaps that hide the flourish of ZCB" and "how to Transition to Mass Market".

Conclusion and future work directions in the field

Looking back on the course of development of Net Zero Energy building, many economies have achieved great progress on NZEB definition and mass market expansion:

1. **NZEB definition.** Economies like Japan, Korea, and United States, have developed specific definitions on residential buildings and public buildings. United States classified the NZEB definition according to its boundary: Zero Net Energy(ZNE) Buildings, Zero Energy Campus, Zero Energy portfolio, Zero Energy Community; Korea have developed a complete set of definition and certification system of zero energy building; Japan   Australia
2. **NZEB best practices.** From 2011 to 2015, the number of NZEB best practices has increased exponentially. There are already more than 20 pilot projects in china, including residential houses, school buildings, and commercial buildings. Energy consumption is still the most important indicator. For Canada, renewable energy such as BIPV is a main adoption during the pilot practices; Fashionable passive and active measures are becoming the focus.
3. **NZEB alliances.** The NZEB alliances have been founded in many economies, including United States, Canada, Japan, Korea, People's Republic of China, Hong Kong, China, Chinese Taipei and so on. These alliances are playing more and more important roles in promoting NZEB to mass market.
4. **Promoting barriers.** Demonstration of NZEB energy consumption is the most important and meanwhile a very complicated thing after the construction stage is completed. Lacking of operating data is the first barrier for APEC regions; Meanwhile Incremental cost for passive approach and renewable energy system is also a barrier that cannot be neglected.
5. **Next step.** For the first, the public awareness should be strengthened that building energy saving by NZEB will is reliable; Second, codes and standards for NZEB design, construction, and operation are needed desperately; And sharing of the newest NZEB development information is also what we should do next, thus to strengthen the capacity construction, to fulfil the mass market step by step.

Acknowledgement

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