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Development of APEC Low-Carbon Town Indicator (LCT-I) System

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Abstract: The APEC (Asia-Pacific Economic Cooperation) LCMT (Low-Carbon Model Town) project was initiated in 2011 as a part of APEC's energy cooperation scheme in response to the rapid urbanization and growing fossil energy use in the developing economies of the APEC region. The LCMT project has conducted feasibility studies and policy reviews for a case town each year and developed and refined the "Concept of Low-Carbon Town in the APEC region (Concept)". The Concept is a guidebook for city planners and developers who wish to implement low-carbon town design. In tandem with the Concept, the "APEC Low-Carbon Town Indicator (LCT-I) System" has been developed since 2013. The LCT-I System is a self-assessment tool to assess and monitor the progress of each low-carbon town development project in the APEC region. The first edition of the LCT-I System Guideline and its evaluation sheet were published together with the final edition of the Concept in 2016. The LCMT project is moving into the dissemination stage beginning in 2017 through the utilization of the LCT-I System. This paper explains the process of the development of the LCT-I System, provides a brief summary and discusses its expected role in the spread of low-carbon towns.

Key words: Sustainable cities, low-carbon towns, indicator system.

1. Introduction

In recent years, the rapid increase in energy consumption because of urbanization in the developing economies[1] of the APEC (Asia-Pacific Economic Cooperation) region has been a major concern. The APEC region represents approximately 60% of the world's primary energy demand [1] and as many APEC economies depend on fossil energy, growing energy consumption is not only a matter of stable energy supply, but also an increasing risk for climate change issues. Therefore, it is acute to take action at the town/city level in addition to economy level policies. In order to encourage the development of LCT (low-carbon towns), promotion of energy efficient measures and installation of renewable energy while taking into account the characteristics of each regions is necessary.

At the 9th APEC Energy Ministers Meeting held in Fukui, Japan, in 2010, the ministers discussed low-carbon paths to energy security and called for the APEC EWG (Energy Working Group) to implement the APEC LCMT (Low-Carbon Model Town) Project to encourage development of LCT and share best practices. The APERC has been working as the secretariat of the LCMT Project since 2011 and its Phase 6 was completed in June 2017. The main objective of the LCMT Project is CO_2 emission reduction in the APEC region. While local government and municipal officials are increasingly interested in developing LCT, their priorities are often alleviating urban problems, such as traffic congestion, air/water pollution, waste management and recycling

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[1] APEC uses the term "economy" to describe members instead of nation or country, to include economies such as Hong Kong and Chinese Taipei which are separate economic entities.

used water. As such, these towns require some level of technical assistance to systematically plan and realize LCT development. This includes setting base years and quantitative low-carbon targets, adopting low-carbon indicator sets, selecting the most appropriate set of low-carbon measures considering the characteristics of the intended town and evaluating the effects of the low-carbon measures adopted. The key activities from Phase 1 to Phase 6 were:

(1) developing and refining the "Concept of the Low-Carbon Town in the APEC region" (Concept);

(2) an FS (feasibility study) of low-carbon development for a selected case town; and

(3) a policy review of low-carbon development policy for the selected case town.

The First Edition of the Guideline and the Evaluation Sheet of the APEC Low-Carbon Town Indicator (LCT-I) System [2] were developed in tandem with the Concept which was first published in October 2011 and the latest version (sixth edition) [3] was published together with the LCT-I System in November 2016. This paper summarizes its background and characteristics and examines the expected role of the LCT-I System in disseminating the LCT in the APEC region.[2]

2. LCMT Project

The Concept is a guidebook for city planners and developers who wish to implement LCT design. It aims to provide a basic idea of LCT and an effective approach to its development so that it can assist government officials in planning effective low-carbon policies and formulating an appropriate combination of low-carbon measures while taking socio-economic conditions and city-specific characteristics into consideration. Together with the experts nominated from APEC member economies, APERC surveyed the effective approaches and low-carbon technologies implemented in the LCT development projects in the APEC region including developed cities. As shown in Fig. 1, the team visited several cities in each phase and updated the Concept each year. The sixth edition [3] is the final for the time being and was published in 2016.

In addition, as shown in Fig. 2, one city/town was selected as a case town for FS and policy review each year in accordance with the theme of each phase. The FS aims at reviewing the CO_2 emissions reduction target and verifying how to develop attractive and innovative development plans taking cost effectiveness into consideration. The policy review was conducted with the experts nominated by APEC economies based on the FS report. The case town in Phase 1 was Yujiapu Central Business District (CBD) Development Project in Tianjin, China, with a focus on greenfield development of a CBD of a large city. Phase 2 was in Samui Island, Thailand, with a focus on low-carbon development on an island resort, Phase 3 was in Da Nang, Viet Nam, with a focus on redevelopment of an existing city, Phase 4 was in San Borja, Lima, Peru, with a focus on a residential area in a city, Phase 5 was in Bitung City, Indonesia, with a focus on an industrial area in a city and Phase 6 was in Mandaue City, the Philippines, with a focus on low-carbon development plans in cooperation with neighboring cities. Phase 7 in Krasnoyarsk, Russia, is underway with a focus on low-carbon development in inland region with high demand for heating and cooling.

Through these activities, it was found that there are many low-carbon approaches being taken in the APEC region and the low-carbon development plans and measures implemented are diverse. It indicates that appropriate evaluation and monitoring from the primary stage of the LCT development planning considering the characteristics of each town is necessary for the efficient dissemination of LCT. Therefore, the LCMT Project began working on the development of the LCT-I System since 2013. In

[2] This paper is a translated and edited version of a paper published in Japanese in Development Engineering, Volume 23 (2017).

Phase 1 (2011)	Da Nang, **Viet Nam**; Surabaya, **Indonesia**; Cebu, **The Philippines**; Putrajaya, **Malaysia**; and Tianjin, **China**
Phase 2 (2012)	Samui Island, **Thailand**; Penghu Island, **Chinese Taipei**; and Da Nang, **Viet Nam**
Phase 3 (2013)	Portland, **The US** and San Borja, **Peru**
Phase 4 (2014)	Vancouver, Calgary, and Toronto in **Canada**; and Philadelphia, **The US**
Phase 5 (2015)	Adelaide and Melbourne in **Australia**; Auckland and Palmerston North in **New Zealand**; and Santiago, **Chile**
Phase 6 (2016)	Yongin and Jincheon in **Korea**; Krasnoyarsk, **Russia**; and Yokohama and Kashiwa in **Japan**

Fig. 1 Cities surveyed for the Concept.

Phase 1 (2011)	Yujiapu, Tianjin, **China** Greenfield development of central business districts (CBD) of a large city
Phase 2 (2012)	Samui Island, **Thailand** Development on an island resort
Phase 3 (2013)	Da Nang, **Viet Nam** Redevelopment of an existing city
Phase 4 (2014)	San Borja, Lima, **Peru** Residential area in a city
Phase 5 (2015)	Bitung, **Indonesia** Industrial area in a city
Phase 6 (2016)	Mandaue, **The Philippines** Low-carbon development plans in cooperation with neighbouring cities

Fig. 2 Case towns of FS and policy review.

cooperation with the case towns of FS and policy review, low-carbon measures and lessons learnt in the process of developing the Concept were reconsidered and included in the LCT-I System.

3. Background of the Development of the LCT-I System

The LCT-I System is not designed for comparison with other cities/towns, but as a self-assessment tool for monitoring the progress of each LCT development project. It aims at assisting governmental agencies to easily conduct periodic assessment in every development stage from planning to maintenance in consideration of various scales, characteristics of LCT development projects in each economy. From the above perspective, we surveyed the trends of city indicators already developed in the world and tried to incorporate the indicators in existing city assessment system. Through the preliminary survey, it was found that the existing indicators are very complicated and designed to evaluate cities in advanced economies where sufficient data are available. Therefore, the existing indicators do not fit the cities in developing APEC economies as many of their LCT are still in the primary stage and they do not have the data necessary for evaluation in many cases [4]. On the other hand, we also found that the CASBEE (Comprehensive Assessment System for Built Environment Efficiency), an existing city assessment indicator system developed by Ministry of Land, Infrastructure, Transport and Tourism of Japan, has some indicators that can be adopted to the LCT-I System [4]. In Phase 4, a prototype of categorization of town types, evaluation method and assessment framework was designed; then sensitivity analysis was conducted in six cities [4]. In Phase 5, the assessment area and each indicator were reviewed and examined. Furthermore, APEC's liaison officer has attended the meetings of the International Organization for Standardization (ISO)/Technical Committee on Sustainable Cities and Communities (TC268) since February 2015 to keep the LCT-I System relevant to global standards developed by ISO [5]. In Phase 6, the final draft was presented to the APEC LCMT Task Force Meeting and LCMT Workshop. The previous LCMT case towns were asked to evaluate their progress since the project implementation using the LCT-I System. Based on the discussions and feedback received in the LCMT Workshop, the First Edition of the LCT-I System Guideline and its evaluation sheet were released in November 2016.

4. Summary of the LCT-I System

4.1 Characteristics of the LCT-I System

Many developing economies in APEC do not have sufficient data, so the LCT-I System was designed to be as simple as possible. The indicators are intuitive and easy-to-understand. Users can utilize existing statistical data where possible and the number of indicator was kept to a minimum. Most of the indicators are qualitative rather than quantitative. The LCT-I System identifies the strength and weakness of a town's low-carbon development. As it is a self-assessment tool, users can evaluate their cities/towns based on their characteristics and development plans. The LCT-I System classifies the characteristics of towns into four types including three types for urban areas: central business district (CBD); commercially and industrially oriented town; residentially oriented town; and one for a rural area (village and island). The evaluation of the indicator for "Town Structure" is based on the classification below in Fig. 3.

4.2 Assessment Area of the LCT-I System

As the low-carbon measures addressed in the Concept were originally designed from the energy perspective, the assessment area of the LCT-I System is first categorized into two main categories: measures "directly related" to energy usage; and measures "indirectly related" to energy usage. The assessment

Type of Town			Characteristics of Town			Infrastructure Development	Laws and Regulations
Symbol	Type		Size	Population Density	Land Usage		
I	Urban	CBD	100ha-	High	Mixed	Sufficient	Sufficient
II		Commercially/ Industrially Oriented Town	-100ha	Middle to High	Mixed	Insufficient	Insufficient
III		Residentially Oriented Town		Middle	Mainly Housing		
IV	Rural	Village Island		Low	Farming Fishing Resort		Limited

Fig. 3 Characteristics of town.

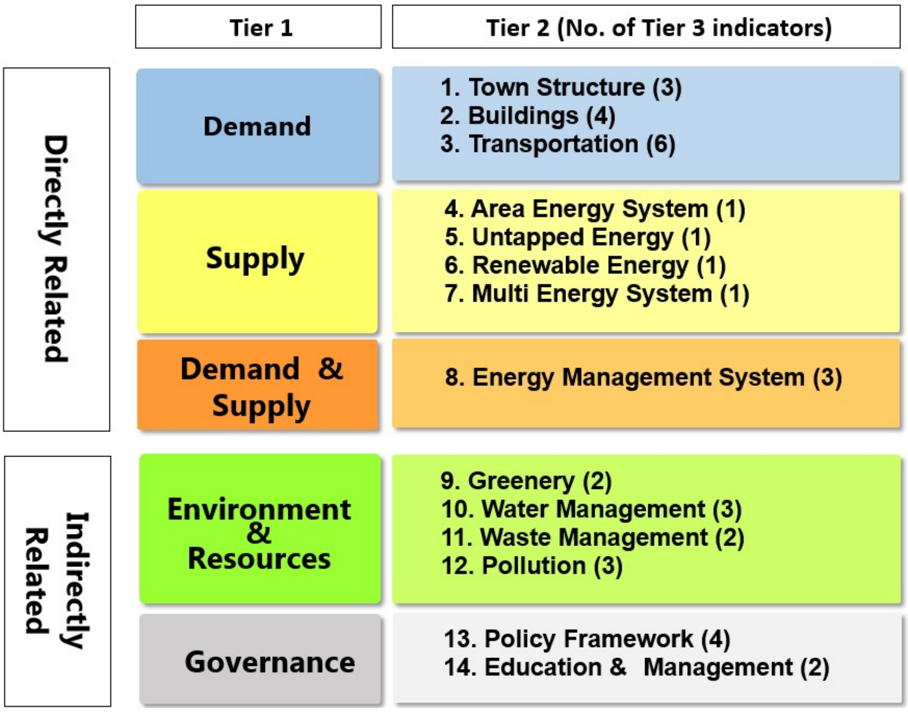

Fig. 4 Assessment area of the LCT-I System.

targets are comprised of five major items (Tier I), 14 mid-level items (Tier II), and 36 lower-level items (Tier III). In directly related measures, low-carbon measures concerning “Demand”, “Supply” and both “Demand & Supply” were included as Tier I items. In indirectly related low-carbon measures, aspects of environment and resources, and governance were included. These are not directly related to energy usage, but they are very important elements in LCT development. In some indicators, evaluation standards in existing assessment indicators, such as CASBEE and LEED (Leadership in Energy and Environmental Design), are referenced and included.

4.3 Scoring Criteria and Assessment Method

The LCT-I System applies a five-point scale for scoring each Tier III item. In the evaluation sheet (spread sheet file), users can choose either, ★, ★★, ★★★, ★★★★, or ★★★★★ based on the explanation for each Tier III item. Depending on the Tier III item, such as “town structure”, “life cycle management”, etc., a three-point scale or a four-point scale may also be applied. In principle, ★★★ will be given as the standard rating where low-carbon plans, systems or criteria of each Tier III item are already in place while no stars will be given if no efforts have been made or the numerical value cannot be measured. Regarding the quantitative assessment area, the achievement level can be evaluated in reference to the standards of each economy, international standards, etc.

Local and central governments are the expected users of the LCT-I System. The evaluation results of the LCT-System are easily reflected in concrete actions such as development of a road map, establishment of a special unit, prioritization of measures, budget planning, etc. As shown in Fig. 5, the self-assessment results will appear as “overall rank,” “radar chart” and “individual assessment,” which will help identify the achievement level of the LCT development project and assessment items to be improved for the realization of LCT.

4.4 Ideas of Tier III Items and Its Evaluation

The background of each Tier III item, brief explanation of each low-carbon measure and its

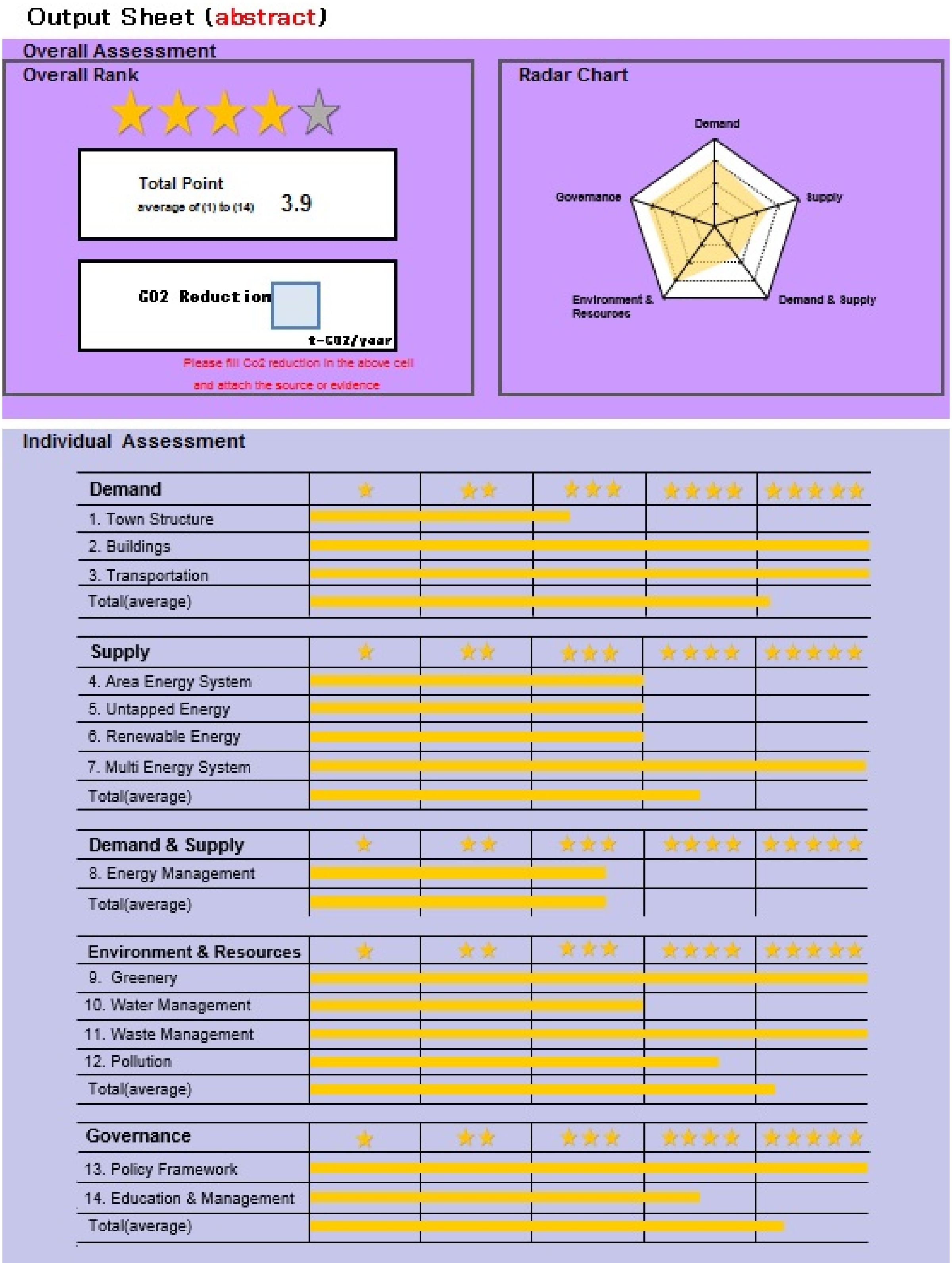

Fig. 5 Image of evaluation result.

evaluation method will be provided in this section.

4.4.1 Town Structure

The amount of CO_2 emissions in cities has been increasing because of chronic traffic congestion caused by unplanned urban development. Urban sprawl is an issue that increases maintenance costs of public infrastructure, such as road/water supply and sewage [6]. Therefore, establishment of a town structure that minimizes the necessity of transfer itself and guidance for TOD (Transit Oriented Development) are needed. Concentration of urban functions and reducing car-dependency will contribute to the improvement of town quality, including punctuality, comfort and control of CO_2 emissions.

Low-carbon measures for town structure include shortening of transit distance and time by locating residential areas adjacent to work areas, promotion of effective land use (utilization of maximum floor-area ratio), multiple land use (concentration of functions of residence, business, commerce, medical care, etc.), as well as development and land use considering traffic hubs such as railroad stations and bus stations.

The indicator for “adjacent workplace and residence” assesses the ratio of residential use or non-residential use to the total floor area of the entire building. As the characteristics of CBD, commercial/industrial areas, residential areas and rural areas differ in land-use planning, the ratio of residential use to the total floor area of all buildings is assessed in CBD and commercial/industrial areas, while the ratio of non-residential use to the total floor area of all buildings is assessed for residential areas and rural areas. In order to assess the concentration of urban functions, the ratio of area used to the standard floor area ratio specified by the land use plan, and presence or absence of multiple use planning is asked. In addition, presence or absence of upper-level plans which promote transit oriented town development is assessed.

4.4.2 Buildings

Energy demand from the consumer sectors (household and business) exceeds 30% of world energy demand and more than half of the energy consumption is for air conditioners/heaters and hot water supply [7]. Thus, consideration of reducing energy consumption for both the building itself and its equipment is important. Not only new buildings but also existing buildings should be taken into consideration when renovated and repaired. In some APEC economies, certification systems and guidelines for low-carbon buildings have been developing. For example, the USGBC (United States Green Building Council) established LEED, which is one of the most internationally recognized certification systems. The application for certification of LEED is increasing all around world. The assessment of LEED is a comprehensive rating system that assesses a building’s environmental performance from various perspectives such as efficient use of energy, water, materials and other resources with consideration to indoor environmental quality, impact on neighborhood environment, etc. In Japan, CASBEE, which was developed with support by the Ministry of Land, Infrastructure, Transport and Tourism, is widely acknowledged and used.

Hardware countermeasures include use of heat insulation, energy saving equipment and natural energy in order to reduce buildings’ energy consumption for air conditioners and heaters. Utilization of natural energy refers to the direct use of daylight, natural ventilation, etc., for air conditioning and lightning as well as to create a comfortable indoor environment without using electricity. These are architectural methods called as passive design (Fig. 6). Software countermeasures include preparation of a certification system and guidelines to standardize energy-saving buildings.

The LCT-I System asks the presence or absence of systems or standards to evaluate the thermal performance and energy-saving performance of buildings. Furthermore, the presence or absence of systems or standards to promote the natural energy

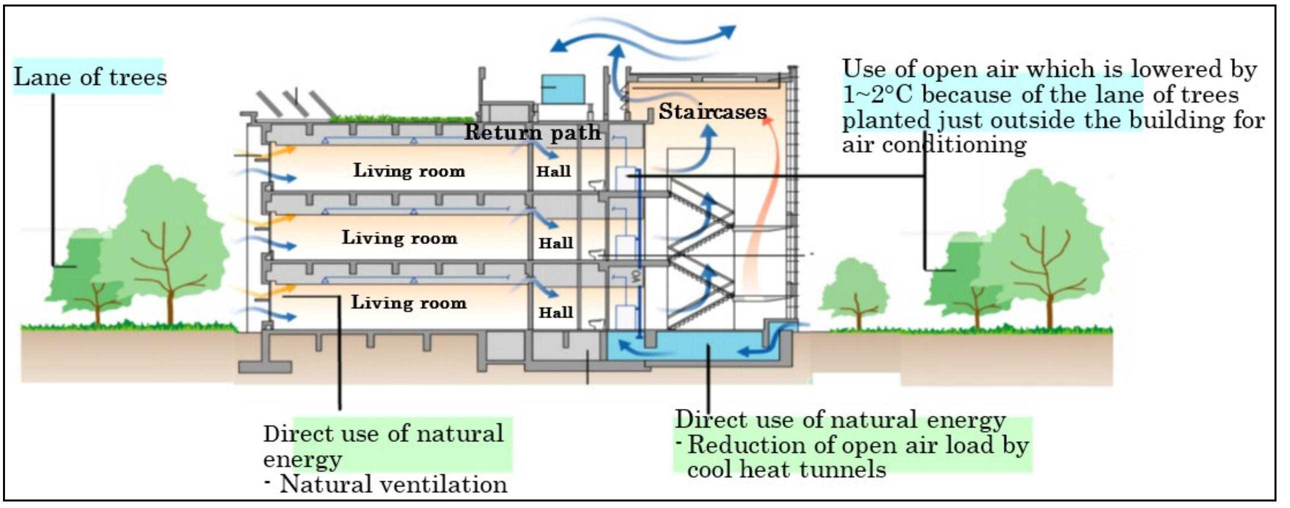

Fig. 6 Natural ventilation using the staircases, Sagamihara Campus, Aoyama Gakuin University.

use such as subsidies and incentive schemes or legally binding regulations, as well as the formulation of the certification system and green building guidelines for the dissemination of low-carbon construction is assessed.

4.4.3 Transportation

The transport sector accounted for 26% of APEC total energy demand in 2013 [1]. The CO_2 emissions per passenger-km show that private automobiles emit 9 times the amount of CO_2, while buses emit 2.7 times compared with railway transportation [8]. In recent years, the ratio of private vehicle ownership in APEC developing economies has rapidly increased and chronic traffic congestion has been a serious problem. Therefore, promotion of public transportation, control of the use of private vehicles and utilization of low-carbon transportation are highly encouraged.

Transportation consists of combinations of various transportation methods. In order to promote the convenience of public transportation, it is necessary to develop transport hubs. Implementation of comprehensive transportation measures including car-sharing, park and ride (P&R), massive transportation systems such as BRT (bus rapid transit), and LRT (light rail transit), and promotion of low-carbon vehicles are effective. In addition, implementation of TOD (transportation demand management), development of highways and interchanges for controlling the traffic congestion and smoothening the traffic flow, as well as promotion of eco driving are other possible measures.

First, the coverage ratio of the areas within walking distance from the train stations and bus stops to the target area is asked to assess if the public transportation system is easy-to-use (Fig. 7). Next, the current situation in the implementation of comprehensive transportation measures such as car-sharing, rental bicycle system, provision of bicycle lanes, etc., is assessed. Furthermore, indicators for the implementation of TDM for the reduction of traffic congestion, the presence or absence of a road improvement plan and an incentive scheme for the promotion of low-carbon vehicles, as well as introduction of eco driving are included.

4.4.4 Area Energy System

DHC (District Heating and Cooling) system is a method to supply cooling water, steam or hot water to multiple buildings with a centralized system. As the supply system is integrated in one location, energy is utilized efficiently and energy-saving is enhanced. Moreover, since space for individual air conditioning/heating system is not required in each building, effective use of spaces such as basement and rooftop is possible.

In the LCT-I System, the presence or absence of an

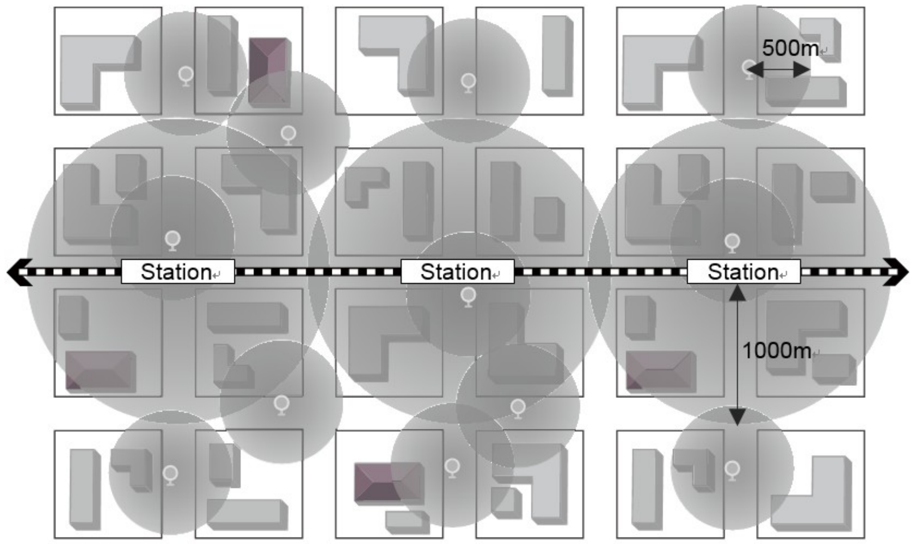

Fig. 7 Walking distance from stations and bus stops.

implementation plan of area energy systems such as DHC, as well as the ratio of energy consumption for annual air conditioning/heating covered by area energy systems is assessed.

4.4.5 Untapped Energy

Untapped energy refers to sources that have not been used in the past, such as: heat from the sea, river and sewage water; exhaust heat from factories, subway and underground shopping area; etc. Utilization of these untapped energy can save energy and reduce the use of fossil fuels as well as CO_2 emissions. However, sources of untapped energy are widely scattered and sometimes located far away from the demand site. Thus, cost effectiveness often remains as an issue. Heat pump systems are recommended as an efficient technology.

The presence or absence of an introduction plan of untapped energy as well as the ratio of annual energy consumption covered by untapped energy is assessed.

4.4.6 Renewable Energy

Renewable energy largely contributes to a reduction in CO_2 emissions and it can be repeatedly used with less resource depletion unlike fossil fuels. Renewable power generation can reduce CO_2 emissions throughout its life cycle from the construction to demolition of the power generation facilities compared with that of the fossil fuels [9].

The presence or absence of the introduction plan of renewable energy use such as sunlight/solar heat, wind power, hydro power, geothermal power, biomass, etc. as well as the ratio of annual energy consumption covered by renewable energy is assessed.

4.4.7 Multi-energy System

As a result of progressive urbanization globally, extensive natural disasters have been escalating the risk of urban management and the constraints of the energy supply system as well as the vulnerability of centralized energy systems have become apparent. At the same time, with the expanded introduction of renewable energy, securing the quality of electricity such as voltage and frequency, is becoming a major issue [10]. In response to such situations, it has become more necessary to disperse the risk of energy supply and reduce CO_2 emissions by combination and optimal utilization of a variety of energy sources like renewable energy, distributed energy and cogeneration in consideration of regional characteristics. Distributed energy is a relative concept formulated in contrast with the conventional large-scale, centralized energy. It refers to CHP (combined heat and power), cogeneration, etc., that is distributed to many different regions on a relatively small-scale.

The benefits of distributed energy include ensuring energy supply in emergency situations while reducing costs and environmental impact through efficient use of energy. In addition, distributed energy has some possible positive side effects such as vitalization of the regional economies, promotion of demand-side participation and reduction of load to the electricity grid. CHP and cogeneration are power generation systems that use fuels such as natural gas, oil and LP gas and generate electricity with engines, turbines and fuel cells, etc., while recovering the exhaust heat simultaneously. The recovered exhaust heat can be used as steam or hot water for air conditioning and hot-water supply, allowing for a more efficient use of heat and electricity. These methods are expected to achieve a high overall energy efficiency of up to 75% to 80% of the fuel's original energy [11]. The introduction of CHP and cogeneration can reduce the total consumption of primary energy by reducing the amount of electricity supplied from the grid system while utilizing exhaust heat for heating and hot-water supply.

The LCT-I System assesses the presence or absence of an introduction plan for CHP and cogeneration.

4.4.8 Energy Management System

An EMS (Energy Management System) can visualize the individual energy consumption of each building such as office buildings and houses as well as the collective energy consumption of buildings in an entire area. EMS enables optimal and efficient use of energy through equipment control. Depending on the type of the targeted buildings/area, there are different forms of EMS such as: BEMS (Building Energy Management System); HEMS (Home Energy Management System); FEMS (Factory Energy Management System); and AEMS (Area Energy Management System), etc. Introduction of AEMS can monitor, analyze and control area-wide energy use in multiple buildings such as offices, shops, houses, etc. It can also support efficient power generation and storage. In addition, installation of a smart grid system which uses ICT (information and communication technology) can control the energy supply and demand simultaneously and achieve an efficient use of energy. At the same time, it can also help stabilize energy supply utilizing renewable energy sources such as solar and wind power. Another effective approach is installation of a micro-grid, which supplies electricity from multiple small-scale distributed electricity sources such as solar, wind and biomass power generation and electricity storage system in the same area. Although this integrated network can be operated independently from the central grid, it could be operated in connection with the central grid or other micro-grids. A micro-grid should be designed, established and controlled based on the needs of the users.

The LCT-I System first assesses the presence or absence of an introduction plan for EMS and AEMS, then also assesses the presence or absence of an introduction plan for smart grid and micro-grid.

4.4.9 Greenery

Greenery is an effective way to create an eco-friendly urban environment. It absorbs CO_2 and mitigates the heat island phenomenon. The effects of evapotranspiration of plants can cool the surrounding temperature, so greenery on the ground, rooftops and wall surfaces of buildings is effective. Making space for green shade (shadows created by trees) contributes to wind paths and cool-spots. It is also important to conserve existing green spaces and surrounding nature.

In the LCT-I System, the ratio of green shade area to the total assessment target area, the ratio of greenery area including water surface to the total assessment target area, efforts of greening and ecosystem conservation of the entire assessment target area are assessed.

4.4.10 Water Management

In many cities of developing economies, because of rapid population growth and increased economic activities, the amount of wastewater from daily life and factories has been increasing, but the development of the wastewater treatment system has not kept up with the demand. It is difficult for a city to ensure budget and land for treatment facilities and maintenance cost of the treatment facilities is also a financial burden.

First, it is important to reduce the volume of water usage and recycle wastewater regardless of whether it is from household or business activities. For facilities with a certain scale, a centralized drainage reuse system can reduce the energy cost of treating and recycling the wastewater. The recycled water can be used for flushing the toilet and other purposes. Establishing a system for using rainwater is also helpful.

The LCT-I System assesses the presence or absence of efforts in water usage reduction, utilization of rainwater and recycled wastewater.

4.4.11 Waste Management

Regulations on waste separation, recycling and volume of waste have not been established in many cities [12]. Landfills are often the most common way to dispose of solid waste in developing economies and open dumping causes spread of bad odor and methane gas (CH_4). CH_4 is considered to have approximately 25 times the effect on the global warming as that of CO_2 [13]. For the effective use of energy and limited resources of the earth, efforts to incorporate 3Rs (reduce, reuse and recycle) are important.

Indicators in the LCT-I System ask the presence or absence of waste reduction goals and efforts being made in waste separation.

4.4.12 Pollution

Typical environmental pollutions resulting from the urban lifestyle are becoming serious problems, such as air pollution caused by automobile exhaust, water pollution caused by domestic wastewater, and soil contamination caused by improper processing of household and business waste. In some of the developing economies, some factories are located in urban areas. Thus, there is a combination of urban-type and industry-type environmental pollution [14].

Efforts to prevent pollution start from setting reduction targets for pollutants and emission standards for each kind of pollutant. Periodic monitoring of released pollutants, publishing the monitoring results and creating programs to protect the health of citizens are also important. In addition, ensuring human resources such as government officials and specialists for pollution prevention measures and training for the staff are highly encouraged. If pollution is not prevented at an early stage, the energy, time and costs to recover human health and environment will be significantly larger than the prevention measures. In recent years, environmental pollution effects from neighboring economies are also becoming a problem. The importance of a shared awareness and taking appropriate joint measures for pollution prevention is increasing more than ever.

The LCT-I System assesses the current prevention measures implemented for the air pollution, water pollution and soil pollution.

4.4.13 Policy Framework

For the establishment of sustainable low-carbon society, the government's strong initiatives are essential in addition to the technologies and efforts of the private sector. For the LCT development, government must make policies, create a project plan and secure a budget. For sustainable development, they also need to develop disaster response and promote development without environmental degradation. Preparation of a LCP (life continuity plan)/BCP (business continuity plan) can help quick recovery from an emergency situation caused by disasters and continue daily life and business activities. The regulations for protecting the geographic features and preventing landform transformation are the basis for the development with low-impact on the natural environment.

The LCT-I System assesses the presence or absence of policies, plans, goals and budget secured for LCT development. Efforts toward sustainability are also assessed by the presence or absence of LCP/BCP, disaster prevention and response measures.

4.4.14 Education and Management

It is important to conduct educational activities so that each citizen of the town can be aware of the importance of low-carbonization and foster a better understanding of the LCT development. In advanced LCT, various stakeholders in the community are engaged in low-carbon activities individually or work together for the LCT development. We can contribute to the low-carbonization from small changes in daily behavior such as turning off an unnecessary light, setting air conditioner and heater at proper temperatures, and stopping littering, etc. If the employers of commercial drivers provide instruction in eco driving, not only prevention of air pollution, but also benefits for their business management are expected as it can reduce traffic accidents and improve fuel efficiency. Therefore, approaches to various stakeholders including the government, developers, residents, companies, educational institutions are effective. In addition to the government and developers, community associations and area management organizations can also take leadership in developing community activities. There are many successful cases in involving the residents from the early stage of planning the LCT development and making progress in an effective and coordinated manner. It is ideal when local community associations share information with each other while expanding and strengthening their network and maintain sustainable activities. Through these low-carbon activities, the town's attractiveness and problem solving ability can also be improved. In doing so, accelerated dissemination of LCT both domestically and abroad is expected.

The LCT-I System assesses the presence or absence of enlightenment activities and environment education (environment studies, eco driving, etc.) as well as establishment and operation of community associations and area management organizations.

4.4.15 Calculation of CO_2 Emissions

The LCT-I System encourages users to calculate the CO_2 emissions of the assessment target area as a part of the actions for the low-carbonization. The methods of CO_2 emissions calculation are up to each economy. For economies that do not have their own standard for calculation, the 2006 IPCC (Intergovernmental Panel on Climate Change) Guidelines for National Greenhouse Gas Inventories [15] and ISO14064 [16] are shown as references. An example of CO_2 emissions calculation using a simplified method in the Handbook of Low-Carbon Town Planning and Implementation [17] developed by the Japanese Ministry of Land, Infrastructure, Transport and Tourism is also shown in the guideline of the LCT-I System. As the LCT-I System is a self-assessment tool, calculation of their CO_2 emissions on a regular basis in order to understand the CO_2 emission sources and control the CO_2 emissions reduction is recommended.

5. Conclusion and Future Plan

The LCT-I System can assess the progress of LCT development in various stages as it includes indicators that assess the presence or absence of the basic standard which is necessary for the primary stage of the LCT development planning as well as the indicators that assess the presence or absence of subsidy system which is important in the maintenance and operation stage of the LCT. The periodic monitoring by the governmental agencies visualizes the progress of the LCT development and makes it easy for the government officials to see what is the next step for them. The efforts can also be an advertising tool that attracts foreign developers, investors and companies, etc. In addition, the Secretariat is exploring the possibility of working together with financial institutions, for example, prioritization of the users of the LCT-I System when they apply for low-interest loans and other support schemes of the financial institutions.

The LCT-I System was developed in cooperation with the government officials, consultants, developers, experts in the APEC region, but the first edition still needs to be examined whether the standard value is appropriate and how variation of subjective evaluation results can be prevented. The LCT-I System needs to be improved through collecting feedback and evaluation samples as a reference as well as reviewing those self-evaluation results.

Currently, Phase 7 is underway and the first LCMT Symposium was held in Jakarta, Indonesia, in September 2017 as a new activity of the project. Banda Aceh City in Indonesia, Hang Tuah Jaya City and Shah Alam City in Malaysia were selected as the LCT-I volunteer towns for Phase 7 and their self-evaluation results were presented by the representatives and reviewed by the experts during the LCMT Symposium. In preparation for the LCMT Symposium, the selected LCT-I volunteer towns' levels of understanding of each indicator in the LCT-I System, evidence that proves the self-evaluation results, and the current level of policy implementation were reviewed. The process is helpful for collecting the appropriate application examples of the LCT-I System and enhancing the capacity building of the developing economies. From 2018, the LCMT Project Dissemination Phase 1 will be started. The second LCMT Symposium is planned in Da Nang, Viet Nam, in September 2018. The LCMT Project will continue to foster an awareness of the need of LCT development in the APEC region.

References

[1] APEC Energy Working Group. 2016a. *APEC Energy Demand and Supply Outlook.* 6th Edition. Volume I. Accessed February 27, 2018. http://publications.apec.org/publication-detail.php?pub_id=1735.

[2] APEC Energy Working Group. 2016c. *APEC Low-Carbon Town Indicator System Guideline.* First Edition. Accessed February 27, 2018. http://publications.apec.org/publication-detail.php?pub_id=1797.

[3] APEC Energy Working Group. 2016b. *The Concept of the Low-Carbon Town in the APEC Region.* Sixth Edition. Executive Summary. Accessed February 27, 2018. https://www.apec.org/Publications/2016/12/The-Concept-of-the-LowCarbon-Town-in-the-APEC-Region-Sixth-Edition.

[4] APEC Energy Working Group. 2014a. *The Concept of Low-Carbon Town in the APEC Region.* Fourth Edition. Appendix 4. Accessed February 27, 2018. http://publications.apec.org/publication-detail.php?pub_id=1692.

[5] APEC Energy Working Group. 2014b. *APEC's Liaison with International Organization for Standardization in the Area of City Indicator Standardization Activities.* Accessed February 27, 2018. http://mddb.apec.org/Documents/2014/EWG/EWG48/14_ewg48_019.pdf.

[6] UN-Habitat (United Nations Human Settlements Programme). 2016. *World Cities Report 2016.* Accessed February 27, 2018. http://wcr.unhabitat.org/main-report/.

[7] METI (Ministry of Economy, Trade and Industry, Japan). 2014. *Annual Report on Energy FY2014.* Accessed February 27, 2018. http://www.enecho.meti.go.jp/about/whitepaper/2015pdf/.

[8] MLIT (Ministry of Land, Infrastructure, Transport and Tourism, Japan). 2007. *White Paper on Land, Infrastructure, Transport and Tourism in Japan FY2007.* Accessed February 27, 2018. http://www.mlit.go.jp/hakusyo/mlit/hakusho/h20/.

[9] CRIEPI (Central Research Institute of Electric Power Industry). 2016. *Comprehensive Assessment of Life Cycle CO2 Emissions from Power Generation Technologies in Japan.* available Accessed February 27, 2018. http://criepi.denken.or.jp/jp/kenkikaku/report/detail/Y06.html.

[10] METI. 2015. *Distributed Energy.* Accessed February 27, 2018. http://www.enecho.meti.go.jp/committee/council/basic_policy_subcommittee/mitoshi/006/pdf/006_05.pdf.

[11] METI. 2012. *References of Combined Heat and Power Promotion Office.* Accessed February 27, 2018. http://www.enecho.meti.go.jp/category/electricity_and_gas/other/cogeneration/pdf/1-1.pdf.

[12] UNEP (United Nations Environment Programme). 2010. *Waste and Climate Change.* Accessed February 27, 2018. http://www.unep.or.jp/ietc/Publications/spc/Waste&ClimateChange/Waste&ClimateChange.pdf.

[13] IPCC (Intergovernmental Panel on Climate Change). 2007. *IPCC Fourth Assessment Report.* Accessed February 27, 2018. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_sy

nthesis_report.htm.

[14] Ministry of Environment. 1991. *Environmental White Paper FY1991*. Accessed February 27, 2018. http://warp.da.ndl.go.jp/info:ndljp/pid/3193736/www.env.go.jp/policy/hakusyo/hakusyo.php3?kid=203.

[15] IPCC. 2006. 2006 *IPCC Guidelines for National Greenhouse Gas Inventories.* 5 Volumes. Accessed February 27, 2018. http://www.ipcc-nggip.iges.or.jp/public/index.html.

[16] ISO (International Organization for Standardization). 2006. *ISO 14064-1:2006 Greenhouse Gases—Part 1: Specification with Guidance at the Organization Level for Quantification and Reporting of Greenhouse Gas Emissions and Removals.* Accessed February 27, 2018. https://www.iso.org/standard/38381.html.

[17] MLIT. 2013. *References of Handbook of Low-Carbon Town Planning and Implementation.* Accessed February 27, 2018. https://www.mlit.go.jp/common/001023245.pdf.