



**Asia-Pacific  
Economic Cooperation**

# **The Concept of the Low-Carbon Town in the APEC Region**

**Sixth Edition**

**Volume I**

**Main Chapter**

Energy Working Group

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## Preface

At the 9<sup>th</sup> APEC Energy Ministers Meeting (EMM9), which was held in Fukui, Japan on 19 June 2010, focusing on the theme 'Low-Carbon Paths to Energy Security', the ministers observed 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'. Responding to this observation, they called for the APEC Energy Working Group (EWG) to implement an APEC Low-Carbon Model Town (LCMT) Project 'to encourage creation of low-carbon communities in urban development plans and share best practices for making such communities a reality'.

The APEC LCMT Project consists of three activities, namely, i) development of the 'Concept of the Low-Carbon Town (Concept)', ii) feasibility study (hereafter 'F/S') and iii) policy review of planned town and city development projects. The LCMT Project is a multi-year project. In the first phase of the LCMT Project, an initial version of the concept was developed, and the F/S and policy review for the Yujiapu CBD (Central Business District) Development Project in Tianjin, China was provided. In Phase 2, the concept was refined with a focus on 'resort area', and F/S and policy review for the Samui Island in Thailand were provided. In Phase 3, the concept focused on 'redevelopment of the existing area', and F/S and policy review were conducted for Da Nang in Viet Nam. In Phase 4, the concept was refined with a focus on 'residential area', and F/S and policy review for San Borja in Peru were conducted. In Phase 5, the low-carbon measures with case examples were updated and governance and environmental aspects were added in the concept in accordance with the draft of APEC Low-Carbon Town Indicator (LCT-I) System. F/S and policy review were conducted in Bitung, Indonesia. In Phase 6, the concept was refined to reflect the low-carbon measures in cold climate region. The sixth edition of the concept is the final edition that includes the First Edition of the LCT-I System Guideline. F/S and policy review for Mandaue in the Philippines were implemented.

To develop the concept, Study Group A was formed, in which experts from interested APEC member economies participated as a task-shared activity. Over the past several years, the concept was refined into a useful guidebook for planners who wish to implement a low-carbon town design, building on the case studies of other low-carbon towns in the APEC region, as well as incorporating practical methodologies for town planning and design. Similarly, Study Group B was formed to conduct the policy review.

As the key advisory body for the APEC LCMT Project, the LCMT Task Force (TF) was established in response to the Energy Ministers' instructions in the Fukui Declaration. LCMT TF is responsible for supporting development of the concept. The Asia-Pacific Energy Research Centre (APERC) coordinates the overall work of APEC LCMT project, including the work of the Study Group A and B under the direction of the Agency for Natural Resources and Energy, METI Japan (Project Overseer).

The concept aims to provide a basic idea of a low-carbon town and an effective approach to develop it. The LCT concept aims to promote the development of low-carbon towns in the APEC region by providing a basic principle that can assist the central and local government officials of the member economies in planning effective low-carbon policies and in formulating an appropriate combination of low-carbon measures, while taking socio-economic conditions and city specific characteristics into

consideration.

The APEC Low-Carbon Town (LCT) indicates a town, city or village which seeks to become low-carbon with a quantitative CO<sub>2</sub> emission reduction target and a concrete low-carbon development plan irrespective of size, characteristics and type of development (greenfield or brownfield development).

The overall plan to develop the LCT proceeds on a step by step basis. The first stage of the plan is to create a basic low-carbon town development plan that builds upon the existing town development plan and the goals and background of the central and local governments' low-carbon plans.

The following stage is the formation of a low-carbon town development strategy which has two essential features to i) set quantitative low-carbon reduction targets with a time frame in which to achieve them and ii) comprehensively select the most appropriate set of low-carbon measures. In this planning process, it is vital to grasp completely the characteristics of the town under consideration, because the physical and governmental characteristics of a town affect the selection of the most appropriate set of low-carbon measures.

There are several different characteristics of towns including climate conditions, geography, industrial structures, town structures or intensity of land uses and town infrastructures. Unlike the first two characteristics, industrial structures, town structures and town infrastructures are variable. Therefore, the government officials responsible for low-carbon town development, especially in the developing economies where rapid growth of towns are being observed, should look at the future picture of the town, or even think about guiding these changes from a view point of reducing CO<sub>2</sub> emissions in the town.

The LCMT project offers a very good opportunity for central and local government officials of APEC economies to refine and enhance their current low-carbon town development plans based on the 'Concept of the APEC Low-Carbon Town'.

The first part of the concept sets out the foundational nature of low-carbon towns, as well as an effective method for their development, taking into account the characteristics of individual towns. The second part of the document outlines the overall planning process for low-carbon towns, including how to set quantitative low-carbon targets. It details a range of measures and/or technologies that can be employed to reduce carbon emissions from both energy supply and demand, effective selection processes optimised for individual situations, and methodologies to evaluate their actual effects.

'The Concept of the Low-Carbon Town (LCT) in the APEC Region - Part II' is intended to be a guidebook for central and local government officials responsible for low-carbon town policies, as well as municipality officials and city planners who are directly responsible for low-carbon town development.

The planning of a low-carbon town requires considerable public input, and it is essential to gain buy-in from leaders of all groups involved and affected (the stakeholders). Though the initial editions of the concept mainly focused on the practical methodologies for low-carbon town development planning and design, Phase 5 highlighted the significance of considering the relationships and roles



of city, state/province and national governments, as well as the importance of the participation of businesses and communities. These issues will be explored at the later stage; this initial concept continues to focus on the practical methodologies for low-carbon town development planning and design.

The 'Concept of the Low-Carbon Town (LCT) in the APEC Region' stresses the importance of setting quantitative low-carbon reduction targets with a time frame for achievement. Most of the towns in the developing economies of the APEC region, however, do not have such targets at present. In the meantime, they have been actively addressing air and water pollution, waste management, and recycling of waste water with numerical targets. It may not be an easy task for cities and towns to set quantitative low-carbon reduction targets.

However, efforts in this direction would help to resolve many of the urban problems they already face. Low-carbon targets can complement and strengthen action aimed toward other targets. For example, low-carbon solutions generally improve air quality, support effective waste management strategies and are closely linked to water management. Moreover, working on and achieving low-carbon development will make towns and cities more attractive and inhabitable. Note that the targets are designed to be town specific and are not broad-based targets that would apply across all APEC economies.

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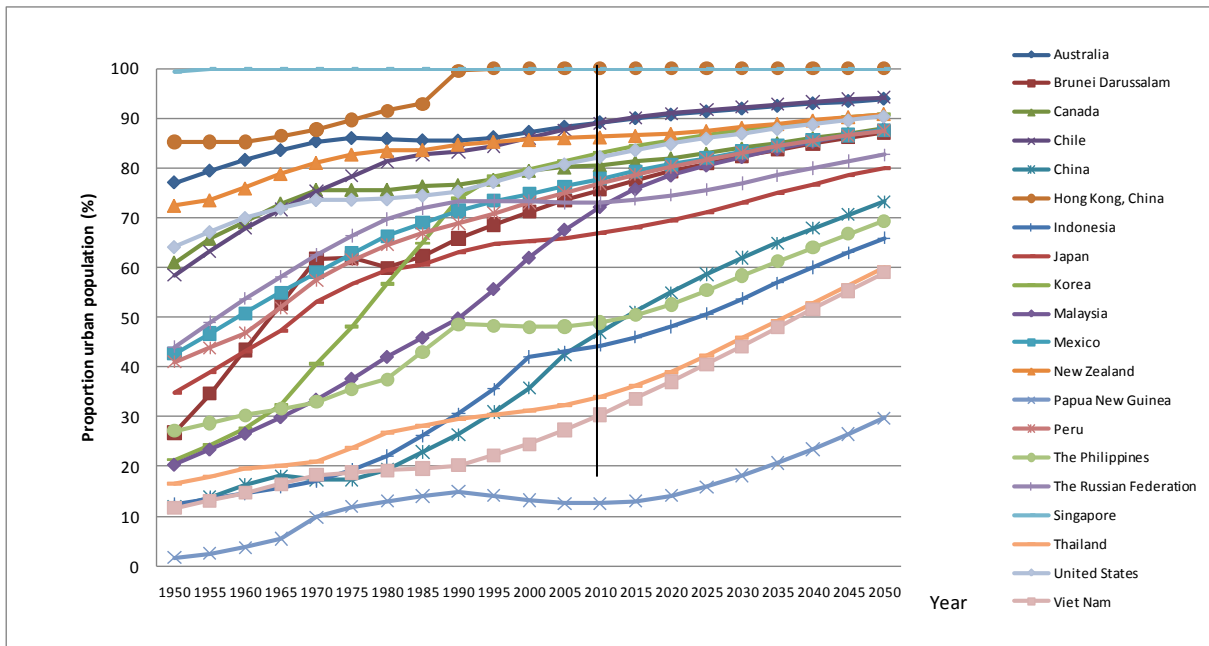


## Chapter 1 Background and Achievement to Date

### 1.1 Urbanisation and its Impact on the CO<sub>2</sub> Emission in the APEC Region

The urbanisation has been progressing in the APEC region. While the average urbanisation rate in all APEC economies in 2010 was 68.5%, it is predicted to be around at 80.9% in 2050. The trend is predominant especially in the economies in Asia such as China, Indonesia, the Philippines, Thailand, Viet Nam, etc. (Figure 1).

Figure 1 APEC Economies Urbanisation Outlook

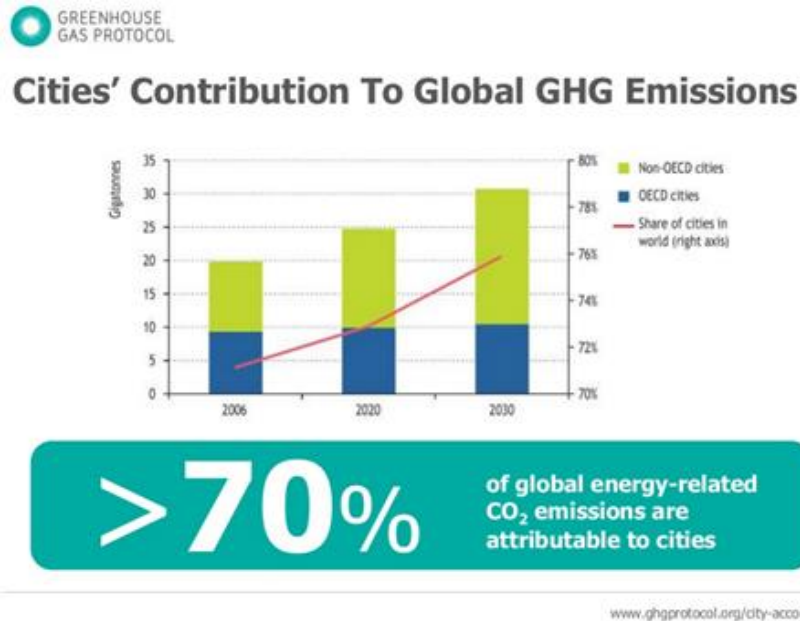


Source: World Urbanization Prospects 2009 (United Nations Development Program)

Energy consumption in the APEC member economies has also increased in response to the economic growth of these economies. The amount of primary energy consumption in the APEC region has increased at an annual average rate of 3.5% since 1990. In 2008, the consumption was approximately 6.8 billion toe (tonne of oil equivalent), an 84.2% increase compared to 1990 and a 26.2% increase compared to 2000.

As indicated in Figure 2, the energy consumption in the urban areas generally exceeds 70% of the total consumption of a nation, and this applies to the APEC member economies. The reduction of greenhouse gas emissions in the urban areas is, thus, a crucial challenge for the APEC economies.

Figure 2 Cities Contribution to Global GHG Emissions



Source: World Energy Outlook, IEA

## 1.2 Global Carbon Context

International frameworks and agreements have been established towards the low-carbon society. These include (1) United Nations' "Sustainable Development Goals", in which the concern on the adverse impacts of increasing emission of greenhouse gas onto the climate change is stated, (2) the Paris Agreement of COP21, under which all the participating countries and regions are obliged to set their "Nationally Determined Contributions", and (3) UN-HABITAT New Urban Agenda, which declares the reduction of greenhouse gas emission.

The member economies of APEC are also supposed to behave in accordance with these international frameworks.

## 1.3 APEC Low-carbon Model Town Project

At the 9<sup>th</sup> APEC Energy Ministers Meeting (EMM9), held in Fukui, Japan, on 19 June 2010, focusing on the theme "Low-Carbon Paths to Energy Security", the Ministers observed that "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". In response to this observation, the ministers called for the APEC Energy Working Group (EWG) to implement an APEC Low-Carbon Model Town (LCMT) Project "to encourage creation of low-carbon communities in urban development plans, and share best practices for making such communities a reality".

The APEC LCMT project consists of three activities as follows.

- i. The development of the 'Concept of the Low-Carbon Town in the APEC Region (concept)',
- ii. The feasibility study (hereafter "F/S") on the selected cities/towns in the APEC region,
- iii. The policy review of towns/cities, where F/S was carried out.

The LCMT Project is a multi-year project and the three activities listed above have been repeated annually.

This document is the 'Concept of the Low-Carbon Town in the APEC region', which is listed at the top of the activities. The concept was first published in 2011, and has been refined every year, reaching sixth Edition in 2016. The earlier editions are available in APEC Publication website (<http://publications.apec.org/>) and APERC's website (<http://aperc.iecej.or.jp/publications/reports/lcmt.html>). The F/S and the Policy Reviews have also been conducted in different towns/cities every year as listed below.

- **Phase 1:** The concept was developed and F/S and policy review were carried out in Yujiapu CBD (Central Business District) Development Project in Tianjin, China
- **Phase 2:** The concept was refined with a focus on 'resort area', and F/S and policy review were made on Samui Island in Thailand.
- **Phase 3:** The concept focused on 'redevelopment of the existing area', and F/S and policy review were conducted for Da Nang in Viet Nam.
- **Phase 4:** The concept was refined with a focus on 'residential area', and F/S and policy review for San Borja in Peru were conducted.
- **Phase 5:** The low-carbon measures with case examples were updated and governance and environmental aspects were added to the concept in accordance with the draft of APEC Low-Carbon Town Indicator (LCT-I) System. F/S and policy review were conducted in Bitung, Indonesia.
- **Phase 6:** The concept was refined to reflect the low-carbon measures in cold climate region. The sixth edition of the concept, which is this document, is the final edition that includes the first edition of the LCT-I System Guideline. F/S and policy review for Mandaue in the Philippines were implemented.

The concept aims to provide a basic idea of low-carbon towns and effective approaches to the development of them in order to promote the development of low-carbon towns in the APEC region. It also assists the central and local government officials of the member economies in planning effective low-carbon policies and in formulation an appropriate combination of low-carbon measures while taking socio-economic conditions and city specific characteristics into consideration.

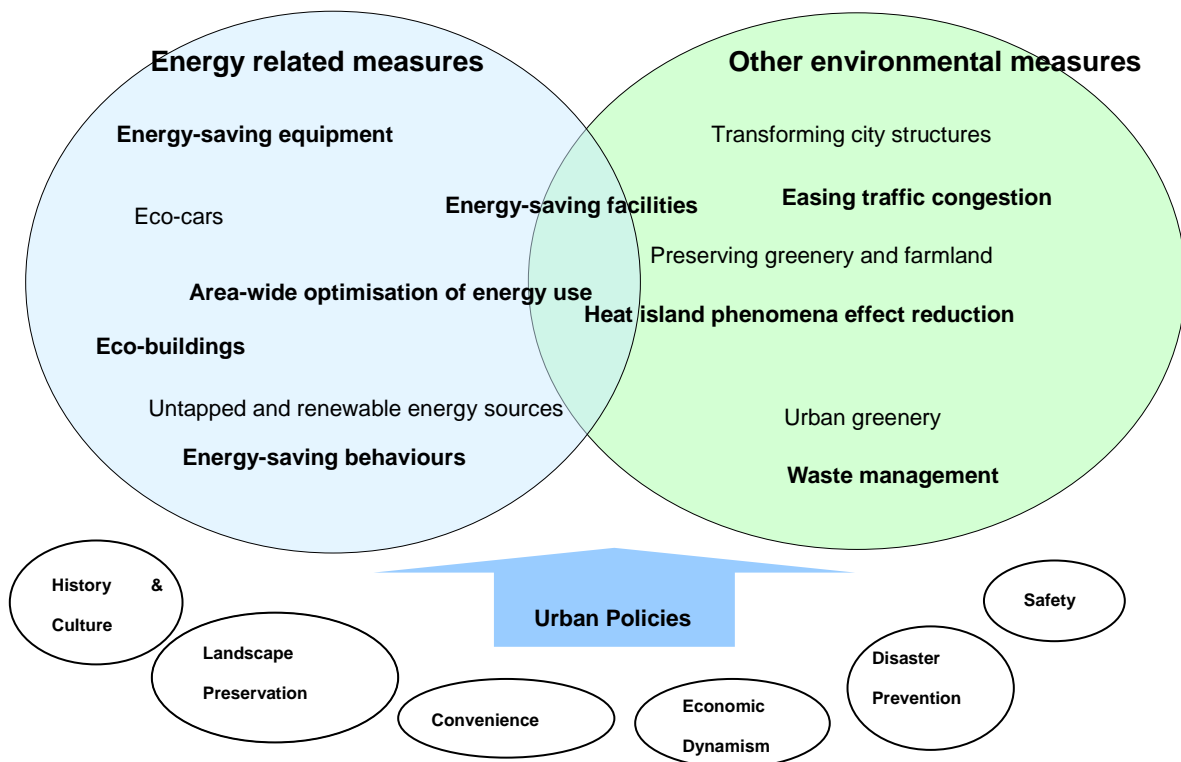
## Chapter 2 APEC Low-Carbon Town (LCT) and Its Concept

### 2.1 The Concept of APEC Low-Carbon Town – The Aims of This Document

The 'Concept of the APEC LCT' aims to provide a basic definition of the APEC Low-Carbon Town and an effective approach to its development, considering the characteristics of the targeted town. The target readers of this concept are the central and local government officials responsible for low-carbon town policies and development plans. The basic approach for low-carbon town development, the characterisation of towns and low-carbon measures will be explained in detail in Chapters 3 and 4.

Figure 3 shows many different types of measures to mitigate CO<sub>2</sub> emissions, which are categorised into two major types namely, 1) energy-related measures that directly result in CO<sub>2</sub> emission reductions, such as the introduction of energy efficient equipment/facilities, use of renewable energy, transportation, etc. (shown in the left-hand circle of the figure), and 2) other environmental measures that indirectly facilitate CO<sub>2</sub> emission reductions, such as recycling, forestation, etc. (shown in the right-hand circle of the figure). The concept will be helpful in the identification of an appropriate set of low-carbon measures to be considered by a town.

Figure 3 Low-carbon Measures



The APEC LCT sets CO<sub>2</sub> emission reduction as a main goal and adopts energy and CO<sub>2</sub>-related indicators. Other indicators, like reduction of car traffic, reduction of waste, reuse of water, etc., are used as supplemental indicators of CO<sub>2</sub> emission reduction. As these measures are interrelated, it is

important to select the most appropriate set of measures when designing low-carbon towns.

During the past several years, various indicators have been used to set the targets and to show the environment-friendliness of urban development projects with the focus on the sustainability in the world. International Organization for Standardization (ISO) has also started a technical committee to define indicators for cities.

Through the revision and refinement of the concept, APEC Low-Carbon Model Town Projects has reached an agreement that a system of indicators for low-carbon towns be established as a part of this projects, and the preliminary study was commenced in 2013.

APEC Low-Carbon Town Indicator (LCT-I) System has been provisionally completed and is included into the Fifth Edition of the Concept as Appendix 4. The APEC LCT-I System will be published as a separate volume of the sixth edition of the Concept.

The APEC LCT-I System is aimed to assist the central and local government officials as well as private stakeholders of low-carbon town/city development as the tool for (1) self-diagnosis of the state of the cities, (2) policy making, (3) target setting of the development, (4) monitoring of the progress of the development, and (5) drawing the future perspective of the cities.

## **2.2 APEC LCT – An Overview on Types of Communities to be Discussed**

The APEC ‘Low-Carbon Town (LCT)’ refers to towns in the APEC region that have a clear target for CO<sub>2</sub> emission reduction, and comprehensive measures to achieve it for sustainable development, and a mechanism to monitor progress towards it.

In this report, a ‘town’ is defined as part of a city, while ‘city’ refers to any size of city ranging from a small city to a big city and a greater city area. As per this report, a ‘district’ is considered part of a town. A ‘town’ also means a village, as a ‘village’ is deemed a smaller agricultural/fishing/resort town/area.

There are two types of low-carbon town developments, namely, greenfield developments and redevelopments of existing cities. In the case of greenfield developments, it will make sense to create a low-carbon development plan for an entire city. In the case of redevelopment, it is not practical to make an entire existing city low-carbon at once. Instead, a low-carbon development will normally proceed on a step by step basis, for example, from one district to another, or from one part of city to another, or by focusing first on some activities and infrastructure.

To summarize, the APEC LCT is defined as a village, town, city or region that seeks to become low-carbon with a quantitative CO<sub>2</sub> emission reduction target and a concrete low-carbon development plan irrespective of size, characteristics and type of development.

Figure 4 shows an example of one approach to the APEC LCT, where the most suitable low-carbon measures are applied to different districts of the town in a comprehensive manner considering cost effectiveness, availability of resources and the characteristics of each district.

Towns in the APEC region have varying degrees of population, population density, economic

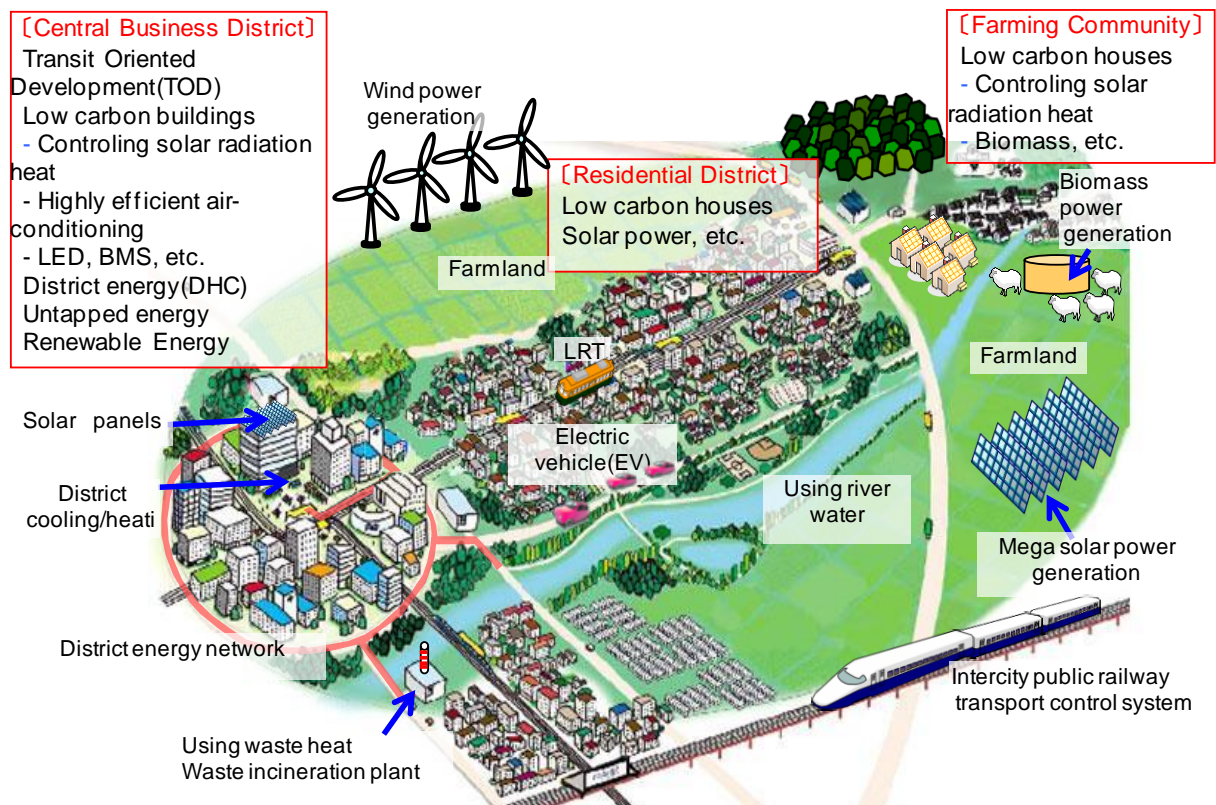


capability, climate conditions and basic infrastructure provision. There are also different land usage patterns observed in these towns. For example, one town may be comprised of mainly businesses and commercial districts, while other towns may be comprised of a primarily industrial manufacturing districts, residential districts, an agricultural town, etc.

Government structures, and the powers and resources of local, regional and national governments also vary. This affects the range of actions a local government can take without engaging with higher levels of government.

The applicable combination of low-carbon measures and available non-fossil energy resources for a low-carbon development will be different according to the characteristics of the town.

Figure 4 Image of Low-Carbon Town



Source: Based on Special Report SR-79, 2008, National Institute for Environmental Studies

### 2.3 Criteria for the Selection of APEC Low-Carbon Model Town for the Feasibility Studies

Since Phase 1 until Phase 7 of Low-Carbon Model Town Project, the case towns for the feasibility study and policy review were nominated upon the criteria stated below.

- The low-carbon development project is coordinated or supervised by a relevant government authority of the APEC member economy. It is ideal if the LCT is in active cooperation with other member economies or cities or regions within them.

- Responsible entity for the low-carbon town development project is identified, and the project is already on-going or has been committed to being implemented.
- The low-carbon development project implementation plan has been developed. The plan should include major items, such as land use plan, transportation plan, energy plan, environment plan and area management plan.
- Organisation and people responsible for the F/S have been identified and have committed to provide necessary information for the purpose of the F/S. The member economy may need to prepare for necessary funding and human resources for internal use.

The F/S, which is conducted under the LCMT Project, provides the local government officials, municipal officials and the developer with a clear and comprehensive assessment of the most appropriate low-carbon measures. It also provides the opportunity to test the viability of the low-carbon development strategies taken. The F/S proceeds according to the process specified in the strategy to develop a low-carbon town discussed in Chapter 3. An ordinary feasibility study is conducted to determine if and how a project can succeed with an emphasis on identifying potential problems, opportunities and potential priority areas/actions before the actual project is initiated. In this sense, the F/S provided by APEC LCMT Project is different from an ordinary feasibility study.

An appropriate set of low-carbon measures to be applied will be different depending on the size of the area and the characteristics of the town. However, the strategy to develop a low-carbon town is essentially the same irrespective of the magnitude and characteristics of the low-carbon development. Therefore, it is valuable to undergo a feasibility study of planned low-carbon development projects in various APEC member economies, where the overall planning process and strategy is reviewed. It is also valuable to have an assessment of policy issues by Study Group B. Policy issues include:

- Identification of regulatory schemes and policy mechanisms appropriate for such issues as land use, energy use, water quality and air quality;
- Organisational adequacy of the government for the town/city/region to promote low-carbon development;
- Investigations into the economic incentives applicable;
- Optimisation of infrastructure investment; and
- Engagement of the citizen and business in the projects.

## **Chapter 3 Basic Approach to Develop the Low-Carbon Town**

### **3.1 Introduction**

There are cities and areas within the emerging economies in the APEC region that have quickly developed in recent years and have not gone through the systematic planning and assessment of low-carbon town development. Given these situations, the necessity of developing a low-carbon concept that defines an effective approach to developing the low-carbon town in the APEC region is increasingly important.

The approach to the low-carbon town (LCT) development consists of five stages from outlining through implementation and management. In 'Stage One', the LCT development plan is outlined within the global carbon context, the policies of central and municipal governments and the master plans of the urban development of the towns and cities where LCT development may take place. In 'Stage Two', a sequence of shaping the outlines into executable plans is carried out through setting quantitative targets and selecting available low-carbon measures. In 'Stage Three', the evaluation of cost-effectiveness and the prioritization of the measures applied and areas to be developed are examined against the budget and finance availability. 'Stage Four' consists of the acquisition of budget and finance, design and engineering, construction and implementation, and of the management of LCT after the completion of construction, including feedback for and improvement of the LCT measures employed. Each stage consists of several steps, as illustrated in Figure 6.

### **3.2 Overall Planning to Develop the Low-Carbon Town**

The procedure for overall planning to develop a low-carbon town is shown in Figure 6. First, when planning a low-carbon town development, a full and complete understanding of the goals and background of the central and local governments' low-carbon plans is indispensable so as to confirm that the low-carbon town development plan is consistent with the economic plan. For this reason, coordination and cooperation with relevant offices in all tiers of government should be pursued as necessary.

The first stage of the overall planning of the low-carbon town is to develop a low-carbon town development plan. This plan is closely associated with the distribution of town functions, land utilisation, control of building density, etc., especially in the case of urban development. Therefore, a low-carbon town development plan should be developed by taking advantage of the ordinary town development plan already in place.

The first step is to clarify the target area, including a clear definition of the town area highlighting the perimeter and boundary of the town, and its nature as a greater city area, a whole city, a district within a town or a block within a district. The next step is to completely grasp the characteristics of the area for development. These are important steps, because ideal combinations of low-carbon measures for creating a synergistic effect will vary depending on the size of the area and its characteristics.

Examples of effective measures for the low-carbon development plan for a big city may include,

strengthening of traffic axes via a public transportation system, such as LRT (Light Rail Transit) or BRT (Bus Rapid Transit), guiding land utilisation to areas near such traffic axes, coordinated creation of a green network along the traffic axes and provision of incentives to utilise lands near unused heat (or cooling) sources. On the other hand, if it is a low-carbon development plan at the level of a district within a town or a block of a district, spatial utilisation of energy tailored to its main activity centres, levelling of energy load through mixed use of various energy sources, demand management and storage, side-by-side development of energy and transportation facilities with parks and other spatial development, and transport and energy management using AEMS (Area Energy Management System) might be effective.

The last step of this planning stage is to develop a low-carbon development basic plan. In that regard, it is essential to take a holistic approach, giving full consideration to other aspects of towns rather than just CO<sub>2</sub> emission reductions, such as economic dynamism, convenience, disaster prevention, etc. in order to develop an attractive and economically sustainable low-carbon town. Developing a low-carbon town relates closely to and shapes the ways of life in the future of the town. Therefore, it is also important to have a transparent decision-making process, including relevant stakeholders, in order to develop a viable plan that gains the full support of the people.

There are some key principles that can be applied at this stage:

- Locate facilities and housing to minimise the need to travel and provide good access to public transport, for example higher density around public transport nodes;
- Make each trip to a destination a step towards being able to reach other likely destinations, so trips for different purposes can be easily combined;
- Ensure adequate amenities are provided for people using or living in areas;
- Provide high-standard telecommunication infrastructure so that 'virtual' service delivery can be used to minimise need for travel, and physical goods and infrastructure requirements can be reduced; and
- Ensure that energy infrastructure encourages efficient, smart energy use and utilises low- and zero-emission energy sources.

There are many stakeholders involved in the planning of a low-carbon town. Therefore, it is not easy to get them properly involved in a transparent decision-making process. At a later stage of the LCMT project, policy issues will be assessed, such as what kinds of regulatory schemes are appropriate for land use, energy use, water quality, air quality, etc. At that time, the issue of a transparent decision-making process will be explored.

The second stage of planning the low-carbon town is to develop its procedure. Key steps of developing a low-carbon town development strategy are to collect necessary energy and CO<sub>2</sub> emissions-related data, set quantitative low-carbon targets, and select the most appropriate set of cost effective low-carbon measures. This will be discussed in the following section in detail.

The third stage is the evaluation of cost-effectiveness of the plan. Volume II of the Concept provide the information on the measures, which can be applied in the APEC region for the development of low-carbon towns/cities.

The last stage is the implementation of the plan, and it consists of financing, design and engineering and construction. The last stage also include the operation phases after the construction is completed, in which the actual effects of the development are measured and the results are fed back to the plans to improve them.

### **3.3 Procedures to Develop the Low-Carbon Town**

It is essential to set quantitative low-carbon reduction targets with a time frame to achieve them, and comprehensively select the most appropriate set of low-carbon measures. These make up the core of the strategy to develop a low-carbon town. The process to follow under this strategy, which starts with collecting energy related data and ends with selecting measures, is shown in Figure 7 in detail. In a greenfield development, strong measures can be applied across the development, while in case of existing development, a transition strategy will be needed, as much 'high carbon' infrastructure and behaviour is in place. In both cases, the underlying aim should be to ensure that long-lasting decisions that 'lock-in' future behaviour.

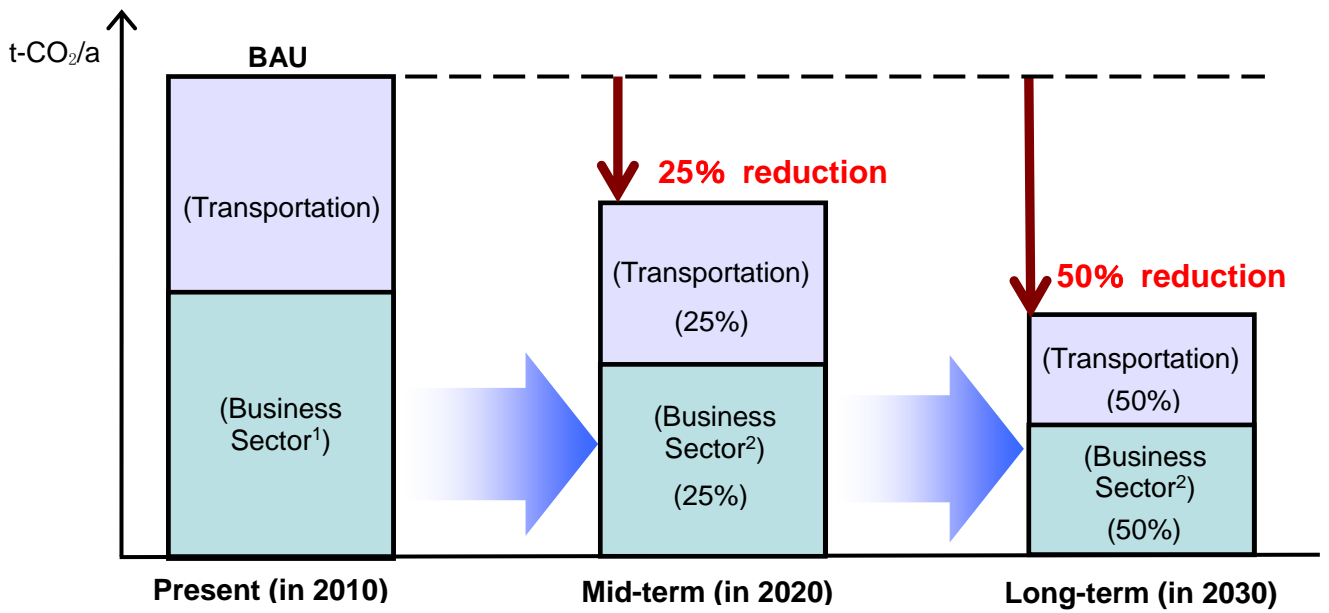
#### **3.3.1 Collection of the Data on Energy Use and CO<sub>2</sub> Emissions**

Baseline energy balance and energy efficiency data for all sectors, as well as predicted future energy consumption. It is important that these data be collected from reliable and consistent sources.

#### **3.3.2 Setting of Quantitative Low-Carbon Targets**

The quantitative low-carbon targets are set for the town as a whole, considering the upper-level low-carbon target, i.e., economy level, provincial level, etc., and characteristics of the intended town. It is recommended to set both overall and sector-specific low-carbon targets, for example, building sector, transportation sector, and residential sector, as a holistic approach is effective to reduce CO<sub>2</sub> emissions across a town. It is also important to recognise that most human energy-related activity will need to be close to zero net carbon emission performance by around 2050, and this has implications for the targets set for long-lived infrastructure, buildings, etc. which will shape energy demand for many decades.

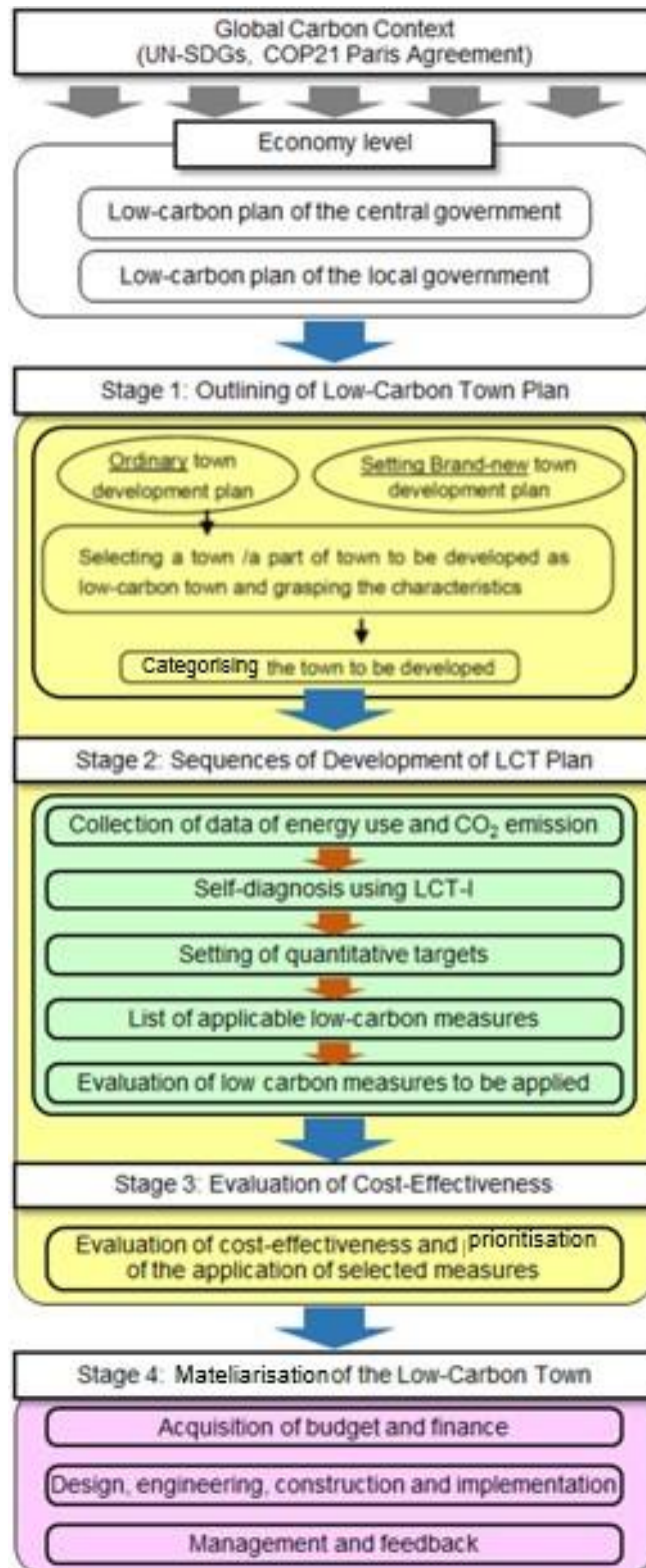
The explanation of how low-carbon targets are set is a so called 'top-down approach'. The targets set in this manner are not backed up by the results of CO<sub>2</sub> reduction calculations, which would result from applying a certain set of low-carbon measures. So, ideally, the target should be supported by an ideas of how much CO<sub>2</sub> reduction is possible by studying actual examples of where the same low-carbon measures were applied to other towns with similar characteristics.

Figure 5 Example of CO<sub>2</sub> Reduction Target

1) Standard type buildings without low carbonised

2) Business sector includes the reduction effects in terms of buildings, district energy, unused /renewable energy, etc.

Figure 6 Procedure of Overall Planning for the Development of the Low-Carbon Town



To evaluate the effect of low-carbon measures, proper indicators should be selected. These indicators will also be used to measure the progress toward the targets in the implementation stage. There are several different indicators to measure CO<sub>2</sub> reduction. The following indicators could be used to assess low-carbon objectives directly:

- Reduction in CO<sub>2</sub> emissions: t-CO<sub>2</sub>/year, t-CO<sub>2</sub>/year- floor space
- Reduction in CO<sub>2</sub> emissions per GDP
- Reduction in CO<sub>2</sub> emissions per person
- CO<sub>2</sub> emission reduction rate (%)
- Reduction in primary or secondary energy consumption: GJ/year

There are other indicators, which could be used complementarily so as to enable a multi-dimensional assessment of low-carbon targets:

- Reduction in the amount of traffic and time taken to access specified services
- Public transportation conversion rate (and low emission transport, such as bicycles, electric bicycles, etc.)
- Reduction in wastes produced and air pollution levels
- Water recycling rate

### **3.3.3 Listing of Low-Carbon Measures**

There are limits to the measures that can be selected to pursue a low-carbon town solely from the perspective of energy supply. However, by combining low-carbon measures concerning energy demand along with supply, greater results can be achieved. A comprehensive low-carbon approach that aims to balance energy supply, demand and consumption is crucial. Smart energy management and storage are also emerging as key elements of a resilient energy system.

For this purpose, the most achievable low-carbon measures that can be adopted in developing a low-carbon town should be screened based on the town categorization, which is discussed in Chapter 4. Then, a listing of these measures will be carried out in terms of energy supply and demand, with more detailed classification on both sides, for example, building, transportation, etc. on the demand side.

It should be noted that, in districts where essential infrastructures—including roads, waterworks and sewerage facilities (and water supply and distribution networks and sewer main networks), and waste treatment centres—are being constructed, it will be important to achieve CO<sub>2</sub> reductions targeted within actual infrastructure development for both operation and energy use for materials and construction.

### **3.3.4 Evaluation of the Effects of Low-Carbon Measures Selected through the Previous Step**

Based on the energy and CO<sub>2</sub> related data, the effect of low-carbon measures in terms of CO<sub>2</sub> emission reduction is to be estimated for each measure using an appropriate method. A variety of simulation models and tools have been developed for conducting comprehensive and detailed simulations of energy-saving measures. These include energy efficiency improvements for different building types (such as office, commercial and residential buildings), area energy systems (such as



DHC (District Heating and Cooling) systems), and technologies for the utilisation of untapped energy supplies, storage and smart management.

The effects are compounded to generate total CO<sub>2</sub> emission reduction, as well as a sub-total of CO<sub>2</sub> emissions by the classification of low-carbon measures. The costs of implementing these measures are also estimated. The method to determine how the effects of low-carbon measures should be evaluated will be explained in Part II of 'The Concept of the Low-carbon Town in the APEC Region'.

### **3.3.5 Selection of the Most Appropriate Set of Low-Carbon Measures**

The most appropriate set of low-carbon measures to achieve the targets is defined by considering the cost required to implement these measures versus the benefits that will be acquired. In some cases, the selection is made in reference to the basic low-carbon development plan, which covers wide-ranging features of the town at present, as well as the future vision of the town. From this perspective, it may be necessary to prepare multiple options.

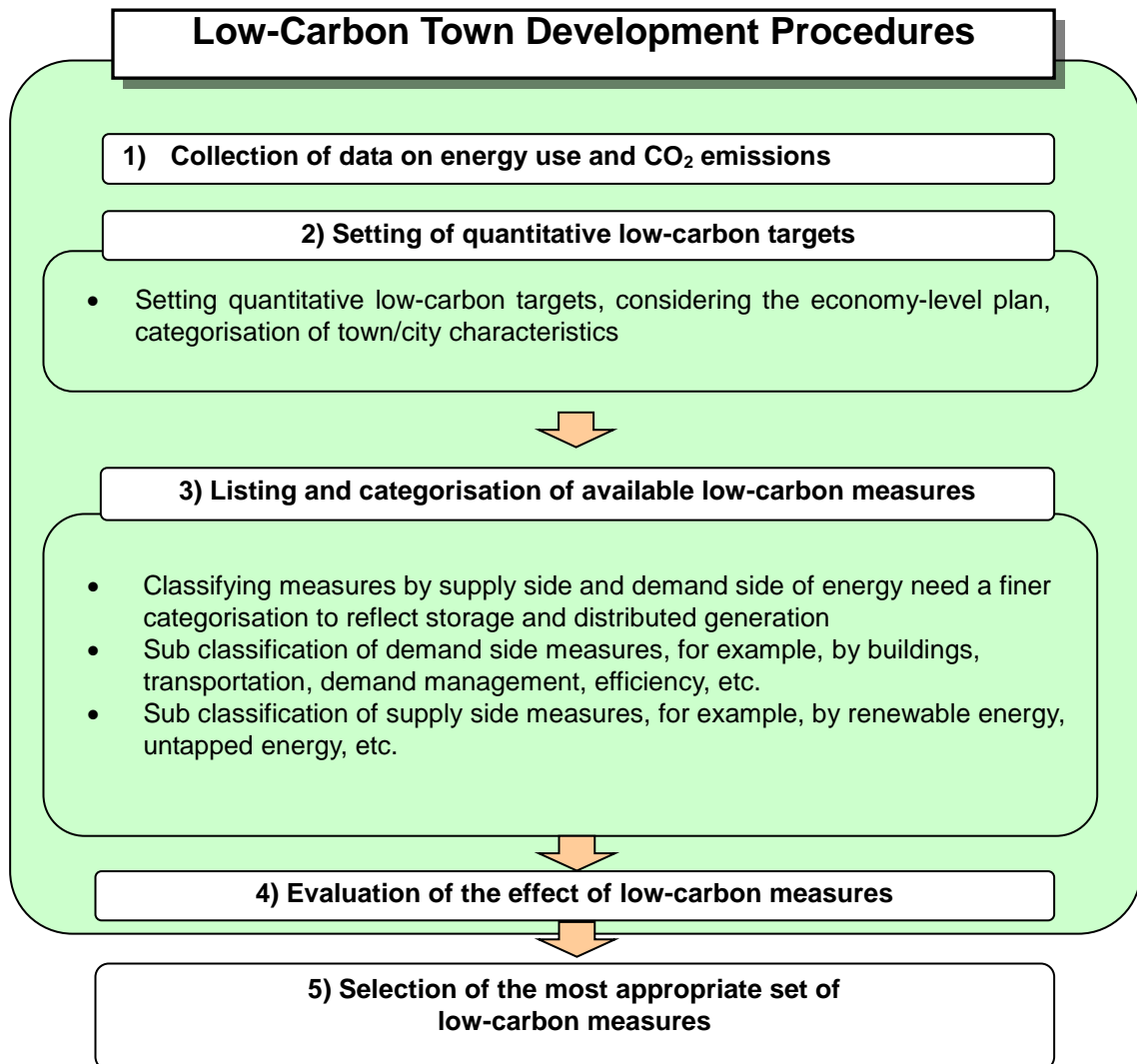
The steps from 3) to 5) are the process used to check the validity of the set targets. The work needs wide-ranging professional expertise of urban design, and therefore, they will normally be commissioned to urban design consultants.

The APEC LCMT Project is designed to provide responsible government officials with the opportunity to assess and refine the low-carbon development plan through conducting F/S.

Rural areas have lower land use density compared to central business districts (CBDs) and can more easily access renewable energy and untapped energy sources from forests, rivers and other natural features. Thus, introducing mega solar power generation, large-scale wind power generation, hydropower generation, and other systems that take full advantage of regional characteristics, as well as on-site or precinct scale solutions, must be proactively considered in these areas. Here, medium- to long-term construction plans that take into account not only current energy efficiency but also efficiency improvements to be gained from future technical innovation should play an important role. The time period and discount rate used for the evaluation must be carefully considered, as a high discount rate or assumed short life can understate the lifetime economic benefit from a long-lived asset.

In the transport sector, under low-density land-use conditions, building railroads and other public transport infrastructure that entail high construction costs will be difficult. Given this, methods that lower the carbon emissions of automobiles, buses, motorcycles and other vehicles (e.g., by using biofuels, using electric vehicles, expanding road-based public transport, etc.) may be practical options.

Figure 7 Low-Carbon Town Development Strategy



### 3.4 Evaluation of Cost-Effectiveness and Prioritisation of the Low-Carbon Measures Selected

Once the list of low-carbon measures applicable to the specific town or the region is formed, the cost-effectiveness of various combination of the measures must be evaluated. This process includes the prioritisation of the measures to fit the plan to the budget available.

The cost of the implementation and the benefit obtained from individual measures differ depending on the economic status and the industrial structures of the economy and region of the projects, the origin of the measures, and on the technological maturity of the introducing economies and regions, and it is, therefore, inadequate to footnote the references on the cost-effectiveness of individual measures.

There are, however, some common bases of considerations on the cost-effectiveness of the

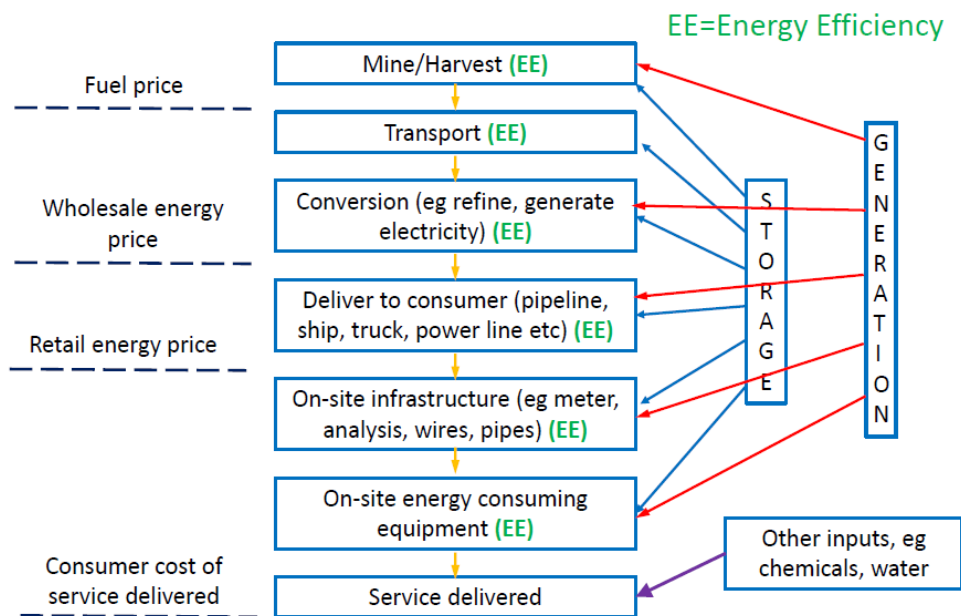
low-carbon measures. First, the cost should be examined on a life-cycle basis rather than the initial cost, since it is commonly observed that an infrastructure investment with low initial expense leads to swelling expenditure during the operations and that the total life-cycle cost far exceeds that of alternatives with higher initial investments. Second, the cost should be investigated along with the financing methods, as some advanced solutions have advantages of governmental aids of other economies and the development projects can apply for preferential treatment of development banks.

## Chapter 4 Characterisation of Towns and Low-carbon Measures

Low-carbon measures are mainly classified according to whether they concern the supply or demand of energy. Cogeneration systems, DHC (District Heating/Cooling) systems, the use of untapped energy (such as waste heat from waste incineration plants) and use of renewable energy (biomass power generation, etc.) are classified as supply-side measures. Meanwhile, TOD (Transit Oriented Development), energy efficient buildings (rooftop solar and storage, etc.), public transportation system and energy management systems are classified as demand-side measures.

Figure 8 Diversity of Energy Options

The 'energy' service delivery system – many options of very different kinds now exist and compete in different markets.



Source: Mr. Alan Pears, Presentation Material at the 2015 APEC Energy Ministerial Meeting

It is worthwhile to mention that depending on the characteristics of town, it makes a difference as to whether these measures can be easily adopted, and/or whether they exert far-reaching effects. So, it is a useful approach to characterise the type of town when selecting the most appropriate set of low-carbon measures and the timeframes over which they may be applied.

There are several different characteristics of towns, including 1) climate conditions, such as solar irradiation, temperature and wind conditions, 2) geography, such as flat landscapes or hilly land, 3) industrial structures, such as the locations of different kinds of industries across the town, 4) town structures or intensity of land use, namely, whether town is developed intensively in 3D space or developed loosely in 2D space, and 5) town infrastructure, whether it is sufficiently developed or not. Access to low-carbon energy sourced from the hinterland or from further afield can also be important, especially if major industry is to be located there, local renewable sources are limited or there is potential for trading of energy at a regional level.

It is worthwhile to note that town structure, as well as its industry structure, changes along with town growth. Therefore, the government officials responsible for low-carbon town development, especially

in developing economies where rapid growth is being observed, should consider the future nature of the town or consider guiding these changes from the viewpoint of reducing CO<sub>2</sub> emissions.

There are several different types of categorisation reflecting the different socioeconomic conditions of towns. Table 1 shows the categorisation, which is based on land-related characteristics, such as size of the town, population density and land utilisation for the purpose of Low-Carbon Town Project.

Table 1 Characterisation of Town

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/Ind ustrially Oriented Town	-100ha	Middle to High	Mixed		
III		Residentially Oriented Town		Middle	Mainly Housing		
IV	Rural	Village Island		Low	Farming Fishing Resort		Limited

City infrastructure, which is categorised by water/environment infrastructure, energy infrastructure, communications infrastructure and mobility infrastructure, supports the wide variety of activities that occur in a city. Therefore, the level of its provision makes a significant difference in evaluating whether a particular low-carbon measure is applicable, especially in the case of introducing an advanced low-carbon technology, such as a smart grid. So, it is an important factor to be considered in selecting the appropriate measures.

Laws and regulations are also an important factor in the development of a low-carbon town. For example, Japan has technologies to utilise raw garbage into energy. However, present national legislations regulate the collection of raw garbage beyond the jurisdiction of the local government, resulting in the delay of practical applications of these technologies.

The list of low-carbon measures along with their applicability based on town categorisation is shown in Volume II.

In the APEC region, there are several towns where a low-carbon development project is ongoing or being planned. These projects vary in size and design approach according to their individual circumstances. The following table shows examples of low-carbon town development projects based on the available information and classified according to the type of town described as above. More examples will be added in the future as there are more planned low-carbon towns in the APEC region.

Table 2 Low-Carbon Town in the APEC

Type of Town	Low-carbon Town Project	Economy	Population
I Urban (Central Business District: CBD)	Yujiapu CBD, Tianjin* <sup>1</sup>	China	500,000
	Quezon City Green CBD	The Philippines	
II Urban (Commercial/Industrial Oriented Town)	Putrajaya Green City	Malaysia	68,000 (300,000 planned)
	Chiang Mai	Thailand	160,000
	Da Nang (Pilot City of WB Eco2 Cities Project)* <sup>3</sup>	Viet Nam	1 million **
	Cebu City (Pilot City of WB Eco2 Cities Project)	The Philippines	820,000**
	Surabaya (Pilot City of WB Eco2 Cities Project)	Indonesia	2.8 million**
	Yokohama Smart City Project	Japan	3.7 million**
	Bitung City (Bitung Special Economic Zone)* <sup>5</sup>	Indonesia	247,405**
	Mandaue City* <sup>6</sup>	The Philippines	365,144**
III Urban (Residential Oriented Town)	Plunggol Eco Town	Singapore	350,000
	Sino-Singapore Tianjin Eco City	China	
	San Borja, Lima* <sup>4</sup>	Peru	
IV Rural	Muang Klang Low-carbon City	Thailand	17,000
	Jeju Island Smart Green City	Korea	6,000 households
	Low-carbon Island (Penghu Island and Others)	Chinese Taipei	88,000
	Samui Island* <sup>2</sup>	Thailand	53,990

\*1 LCMT Phase 1 feasibility study

\*2 LCMT Phase 2 feasibility study

\*3 LCMT Phase 3 feasibility study

\*4 LCMT Phase 4 feasibility study

\*5 LCMT Phase 5 feasibility study

\*6 LCMT Phase 6 feasibility study

\*\*Total population

**C40 Cities**

*C40 is a network of the world's megacities committed to addressing climate change. C40 supports cities to collaborate effectively, share knowledge and drive meaningful, measurable and sustainable action on climate change. The C40 Cities Climate Leadership Group, now in its 10th year, connects more than 80 of the world's greatest cities, representing over 600 million people and one quarter of the global economy.*

*Created and led by cities, C40 is focused on tackling climate change and driving urban action that reduces greenhouse gas emissions and climate risks, while increasing the health, wellbeing and economic opportunities of urban citizens.*

*Tying together the powers of cities with the urgency in managing urbanization, within C40 cities there is the Low-Carbon Districts Network which seeks to help create new models for district-scale development and integrated planning.*

Source: C40 Cities (<http://www.c40.org/>)



## **Chapter 5 Measures Applicable to the Development of Low-Carbon Town**

As shown in Figure 9, low-carbon measures can be categorised under these headings:

1. Town Structure
2. Buildings
3. Transportation
4. Area Energy System
5. Untapped Energy
6. Renewable Energy
7. Multi Energy System
8. Energy Management System
9. Greenery
10. Water Management
11. Waste Management
12. Pollution
13. Policy Framework
14. Education & Management

As the measures addressed in this concept were originally designed from the energy perspective, they were first categorized into two main categories based on if they were 'directly related' or 'indirectly related' to energy usage. 'Directly related' measures concerning demand, supply, and both demand and supply were included. Measures Types 1-3 concern energy demand and Types 4-7 concern energy supply, while Types 8 straddles both energy demand and supply. From the Fifth Edition, the elements of 'Environment & Resources' and 'Governance' were added. Those two aspects are not directly linked with measures concerning energy, so they have been placed under the 'indirectly related' measures. Though the contributions of Types 9-14 are indirectly related to energy, they are very important to take into account in order to effectively approach the development of low-carbon towns. An overview of these measures and the basic ideas concerning how to introduce them are provided in the following sections.

Figure 9 Categories of Assessment

	<b>Tier 1</b>	<b>Tier 2</b>
<b>Directly Related</b>	<b>Demand</b>	1. Town Structure 2. Buildings 3. Transportation
	<b>Supply</b>	4. Area Energy System 5. Untapped Energy 6. Renewable Energy 7. Multi-Energy System
	<b>Demand &amp; Supply</b>	8. Energy Management System
<b>Indirectly Related</b>	<b>Environment &amp; Resources</b>	9. Greenery 10. Water Management 11. Waste Management 12. Pollution
	<b>Governance</b>	13. Policy Framework 14. Education & Management

## 5.1 Measures on Energy Demand

### 5.1.1 Low-Carbon Urban Structure and Land Use

#### i) Low-Carbon Urban Structure (TOD Type Land Use)

Transit Oriented Development (TOD) aims to create a town having transport based on walking, low-speed vehicles (e.g. bicycles and mobility scooters) and public transportation systems, not dependent on automobiles with their many impacts, and occupying much less urban space per unit of mobility. TOD has the following specific development means.

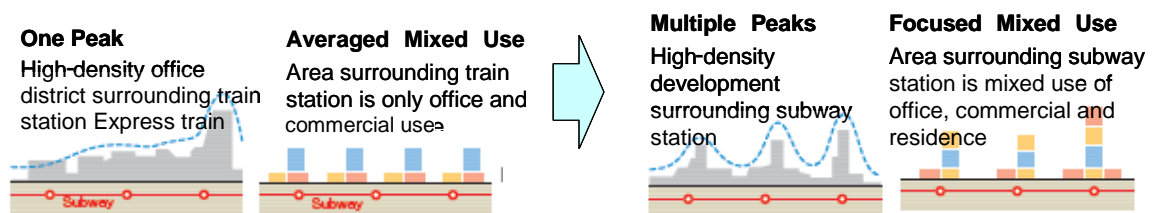
- Build a less CO<sub>2</sub>-emitting town area by improving the land use (i.e. Concentrating a broad range of urban functions around the main transportation nodal points) and through systematic development of commercial, public and residential areas.
- Build a town area whose transit is based on walking, bicycles, buses, etc. without depending on private vehicles. The aim is to provide convenient, quick, safe and low environmental impact access to the services individuals and businesses need to function.

#### < TRANSIT MALL >

Many towns in APEC developed economies have established a commercial space called a Transit Mall. It limits the car ride, and allows pedestrians and mass transit systems, including buses and tramcars. Transit Mall is expected to vitalize the central built-up areas, and improve road transportation environment and public transportation services.

When residential and office buildings are planned in the same area, energy demand equalization and/or energy sharing systems offer the potential to absorb different peak energy demands.

Figure 10 Image of High Density Development Surrounding Train Stations



#### <TOD Examples>

Creating a plan—New Zealand Transport Strategy

<http://www.transport.govt.nz/ourwork/Documents/NZTS2008.pdf>

Transport oriented development in Subiaco Australia:

<http://www.mra.wa.gov.au/Projects/Subi-Centro/About-the-Project/>

Bicycle Network in Chinese Taipei: <http://biking.cpami.gov.tw/Page> (in Chinese Only)

## **ii) Low-Carbon Land Use**

Given predictions that population and economic growth will continue in the APEC region, it is anticipated that urbanisation of suburban, rural and island areas will expand, leading to greater numbers of cars and buildings, unless alternative solutions are applied. This makes it necessary to formulate and execute plans that are founded on future population growth, population composition and economic growth in such areas. Plans should include encouraging use of appropriate development sites, use of low-carbon buildings and systematic development of public transportation.

Urban planning in developed economies that are grappling with aging societies and falling birth rates is required to change land-use planning for decreasing populations, including suburban 'smart shrinkage' or land-use planning well-coordinated with public transportation plans. Given declining populations and societal aging, challenges are likely to emerge in the future in regions that are currently enjoying continued economic growth. Therefore, land-use plans that take into account similar changes in socioeconomic conditions should be prepared at the present time.

### **5.1.2 Low-Carbon Buildings**

In office and commercial buildings, a lot of electricity and heat energy is used for air conditioning, lighting, office automation (OA) equipment and hot-water supply. At the same time, inefficient equipment releases large amounts of heat into buildings, increasing cooling requirements, while (inefficiently) reducing heating requirements. The same conditions apply to residential buildings, although on a different scale. When evaluating the low-carbon building measures, it is advisable to follow the following three steps as they will lead to more efficient and cost-effective CO<sub>2</sub> reduction:

- 1st Step: Reduce heat load into the building through rooftop greenery and improvement of the heat insulation of the windows, etc.
- 2nd Step: Deploy passive energy design, such as natural lighting and natural ventilation.
- 3rd Step: Improve energy efficiency in air conditioning, lighting equipment, etc.

There are many reduction measures within each step. It is necessary to examine the most appropriate combination of measures considering the use, targeted CO<sub>2</sub> reduction amount, construction cost, etc. of the intended buildings.

#### **i) Reduction of Heat Load in the Building**

Evidence shows that heat-energy demand for cooling/heating and electricity use for lighting and equipment depends greatly on the structure of the building, its outer environment and the use of the building.

In order to reduce CO<sub>2</sub> emissions associated with the building, the first step is to consider measures that will create a comfortable work and living environment in the building using less energy, in other words, the measures that will reduce the building load. In many retail buildings, such as supermarkets and restaurants, energy use and heat generated by equipment can dominate the energy demand of the building.

Compared to large-scale businesses, commercial buildings, large hotels, or high-rise residential complexes, it will be difficult for small- and medium-sized resort hotels (comprised of cottage-type buildings) and low- and medium-rise housing to introduce centralised energy supply systems (e.g.,

DHC (District Heating/Cooling) system, central heat sources, central hot-water systems, etc.) Here, the further introduction of highly efficient equipment and facilities, such as high-efficiency air conditioners, heat-pump water heaters and latent heat recovery-type water heaters, plays a very important role in reducing a building's CO<sub>2</sub> emissions.

Where central systems are used, attention must be paid to minimising distribution and standby losses associated with pipes, ducts, fans and pumps, and maximising flexibility of operation as these factors can seriously undermine overall energy efficiency, especially under low-load conditions.

In addition, for small buildings, reinforcing insulation by using rooftop greenery, solar reflectance paint on roofs, etc., as well as the use of natural energies (natural ventilation and natural lighting), will amplify the effectiveness of CO<sub>2</sub> reduction methods and should be actively introduced.

In many climates, and when building fabrics are efficient, energy use for appliances and equipment can exceed that used for heating and cooling, as well as injecting unwanted additional heat into buildings.

Especially where buildings are very efficient or climates are very mild, the amount of energy used to produce the materials used for construction can be significant on a life-cycle basis. Therefore, the use of materials with low embodied energy and carbon emissions, and efficient utilisation of materials are issues of increasing importance.

#### <Low Cost Strategies>

There are also strategies to apply to increase comfort and cut energy use in poor quality buildings. In several developing countries, extreme discomfort and energy waste in many small residential and commercial buildings, such as low cost housing, roadside commerce, etc. are seen. Attempting to cool a building that has an uninsulated corrugated iron roof or is open to outdoor air is very energy wasteful. Low-cost strategies, such as painting roofs white (or light colours), using curtains to zone spaces, adding insulating panels, and improving air conditioner maintenance (especially cleaning filters and heat exchangers), may prove to be useful not just in saving energy and reducing peak demand, but also educating people about what a difference a thorough/integrated approach to energy can offer.

### ii) Adoption of Passive Energy Design

It can be effective to adopt passive forms of environment-friendly technology, which make use of sunlight, solar heat, wind and geological conditions to adjust the indoor environment. For example, these may include building layout, envelope, geometry, infiltration and air-tightness design that can assist in utilising natural lighting or ventilation to obtain the desirable indoor environment quality. However, these approaches may be less appropriate under some conditions, such as in highly polluted cities or where the climate is extreme.

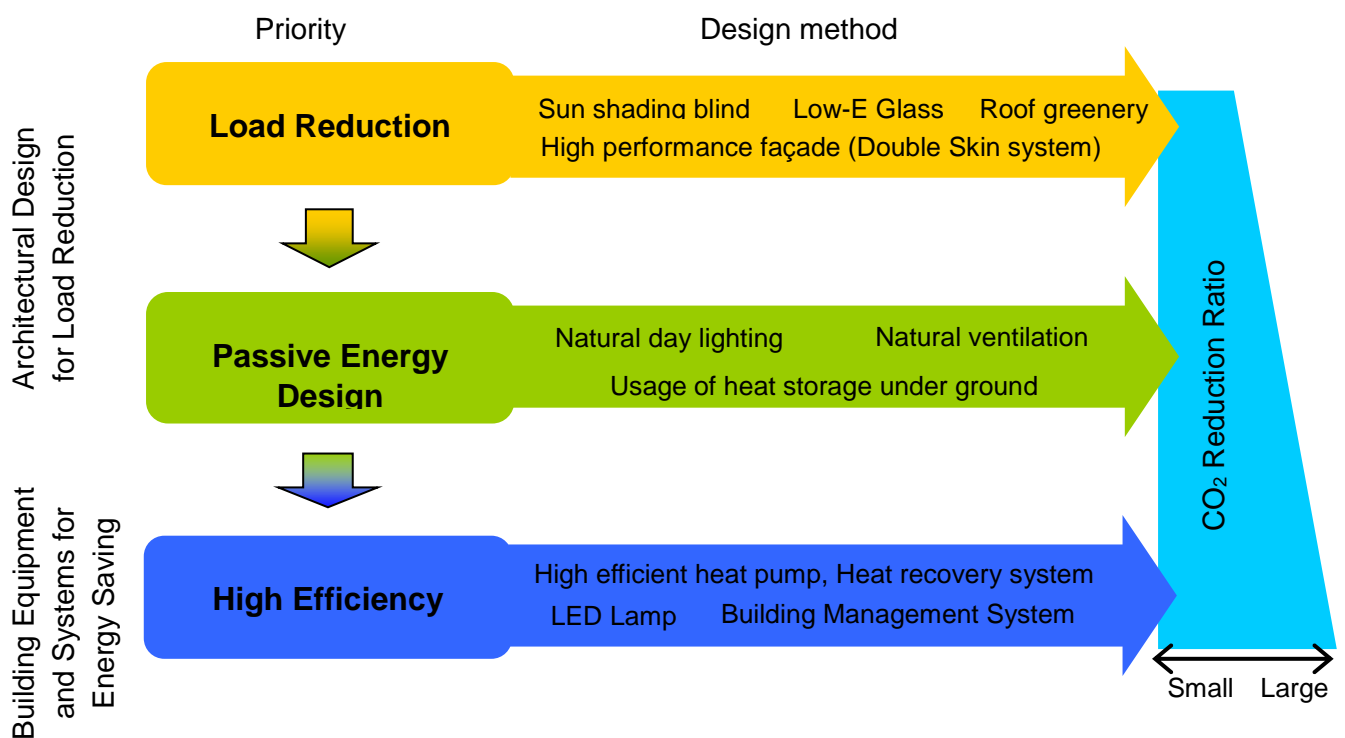
In the central built-up areas of large cities, the 'heat island' phenomenon is of serious concern, because of the volume of heat released into the atmosphere from rooftop cooling towers, road traffic and pedestrian pavements. In this case, solar radiation reaching a building's rooftop is converted into

heat, which causes higher room temperatures and rising air-conditioning costs. Thus, applying high-solar reflectance paint for roof surfaces prior to the conversion of solar radiation into heat is effective in controlling rising room temperatures and lowering air-conditioning energy requirements.

### iii) Improvement of Equipment Efficiency

Energy use in the building can be reduced by adopting high-efficiency equipment for functions, such as air conditioning, lighting, office automation and hot-water supply. A schematic design flow of a low-carbon building is shown in Figure 11.

Figure 11 Schematic Design Flow of Low-carbon Building



### 5.1.3 Low-Carbon Transport

#### i) Low-Carbon Measures in the Transportation Sector

Most of the CO<sub>2</sub> emissions from the transportation sector come from motor vehicles. CO<sub>2</sub> emissions from vehicles are represented as the product of traffic volume, distance travelled (trip distance) and emission intensity of automobiles. It follows that the low-carbon measures for the transportation sector will be based on measures to reduce values of these three factors by:

- a Reducing the distance that needs to be travelled, for example, through promoting a compact well-organised city, which shortens the commuting distance and makes walking or bike riding more attractive.
- b Reducing traffic volume through promoting the shift to walking or bicycling and using mass transit systems, such as carpools and buses, which have less per capita CO<sub>2</sub> emissions than automobiles. Where electric mass transit is used, it is more easily shifted to renewable energy and creates less local air pollution than liquid-fuelled transport.
- c Reducing intensity of CO<sub>2</sub> emissions per unit distance travelled through improving the road conditions to reduce time spent in traffic, introducing more fuel efficient vehicles, using alternative fuel vehicles and eco-driving.

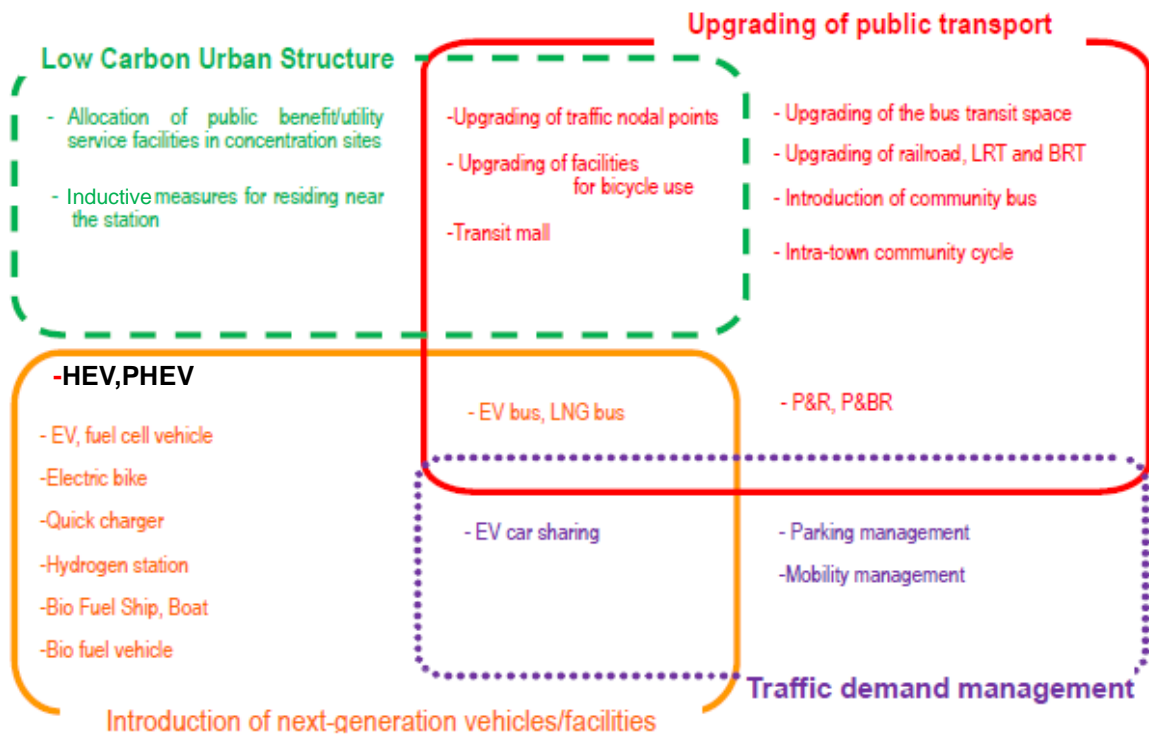
Figure 12 shows how these low-carbon transport measures can be integrated in low-carbon town structures.

The effects of measures to reduce CO<sub>2</sub> emission may not be obtained as anticipated if the measures are implemented individually. It is recommended that measures are implemented in ways where the greatest synergetic benefits can occur. The most important approach is to combine promotion of public transit systems with traffic-demand management for motor vehicles. In addition, it is recommended to review how well the existing public transit facilities fit the requirements of the particular town.

Urban road freight, particularly light commercial vehicles, can be a major contributor to traffic congestion, fuel use and urban pollution. Many light commercial vehicles carry small amounts of freight. Improved coordination of freight activity can offer significant benefits.

It should be noted that applying fuel-efficiency regulations on vehicles introduced in an economy together with measures in the targeted town will make it possible to promote lower CO<sub>2</sub> emission in both the targeted town and the economy as a whole. Stronger enforcement of pollution standards must be implemented to ensure regulations achieve intended outcomes.

Figure 12 Combination of Low-Carbon Traffic Measures





### <Changes in CO<sub>2</sub> emissions in Japan's transport sector>

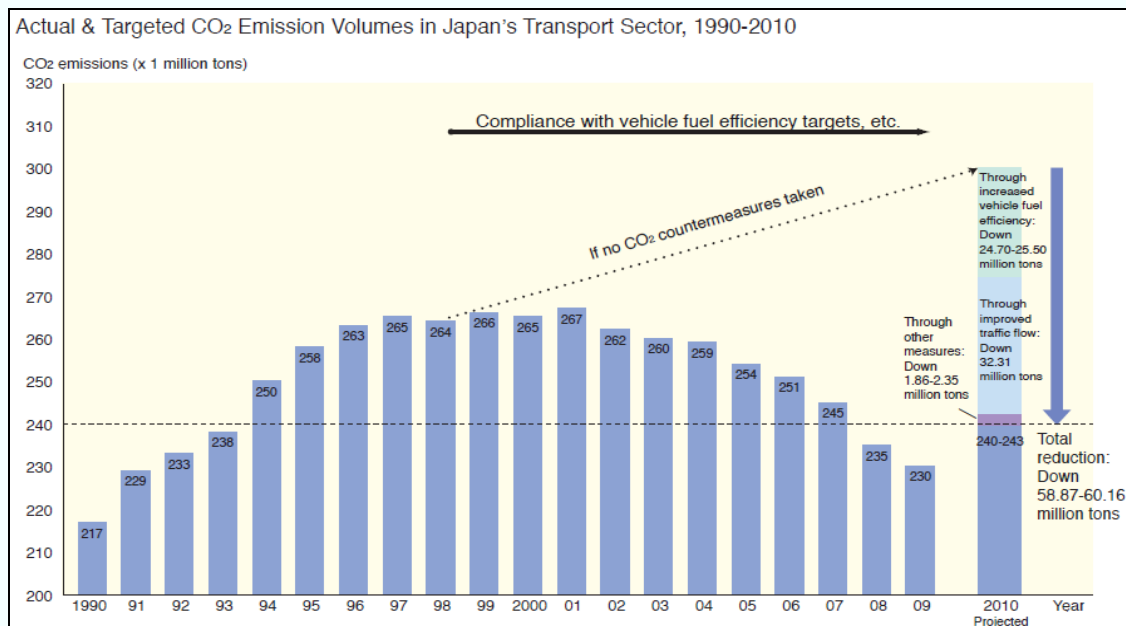
*In Japan's transport sector, CO<sub>2</sub> emissions have been steadily declining since peaking in the early 21st century. This decline is the result of successful implementation of the following integrated measures.*

*Road transport accounts for approximately 90% of CO<sub>2</sub> emissions in the transport sector. The volume of CO<sub>2</sub> emissions in the transport sector is obtained by multiplying the actual driving fuel efficiency, the CO<sub>2</sub> emission coefficient, and total distance travelled. Effective means of improving actual driving fuel efficiency include not only improving the fuel efficiency of individual vehicles, but also alleviating traffic congestion through traffic flow measures and efficiently employing 'eco-friendly driving'. Improving the CO<sub>2</sub>-emission coefficient requires the introduction of next-generation vehicles using alternative fuels that emit little CO<sub>2</sub> (electricity, hydrogen, natural gas, biofuels, etc.). Effective ways of reducing total travel distance include improving the transportation efficiency of freight vehicles and appropriately combining public transportation systems and personal mobility (i.e., introducing a modal shift, improving quality of experience of public transport).*

*The comprehensive implementation of the above-mentioned measures successfully reduced CO<sub>2</sub> emissions in the transport sector from 267 million tons at their peak in 2001 to 240 million tons in 2010.*

*The most rational way forward in reducing CO<sub>2</sub> emissions in the transport sector is to take integrated approaches—raising fuel efficiency, improving traffic flow, supplying appropriate fuels, using efficient vehicles, encouraging a modal shift, etc.—that involve all stakeholders, including automobile manufacturers, government, fuel businesses and automobile users. The introduction of policies and measures to realize these approaches in ways that take regional characteristics into account is thus desired.*

*The potential of telecommunications to reduce and optimize transport energy use is significant. Growing popularity of personal media devices is also influencing desirability of travel modes that allow continued use of smart phones and personal media devices. In some countries this seems to be a factor in reduced car usage and ownership, especially among younger people.*



Source: Japan Automobile Manufacturers Association, Inc.

## ii) Upgrading of Public Transit Systems

Public transit systems can reduce CO<sub>2</sub> emissions by reducing the volume of traffic of private vehicles, such as automobiles and motorbikes. They can also reduce traffic jams and travel time.

There are many types of public transportation system, including standard bus, bus rapid transit (BRT), light rail transit (LRT) and subway or metro systems. It is crucial to select the most appropriate system to match the town size and traffic demand. As shown in Figure 13, the capacity of a bus system is about 6,000 passengers per hour per direction, while that of an LRT system is 6,000-12,000 passengers and a metro system is efficient for loads of above 25,000 passengers per hour per direction. Figure 14 illustrates the variation in capital cost between the different forms of public transportation.

Increased use of public transit systems can be promoted by improving the convenience of connections between different modes of transit, such as at train stations. Features to consider include barrier-free design, comfortable and safe spaces for pedestrians, people waiting for services, and bicycle-parking areas.

Figure 13 Transportation Capacity by Traffic Mode

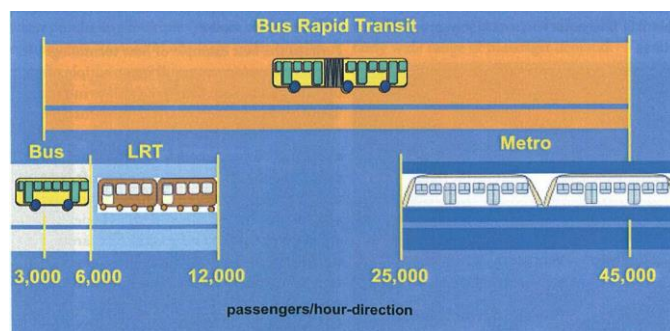
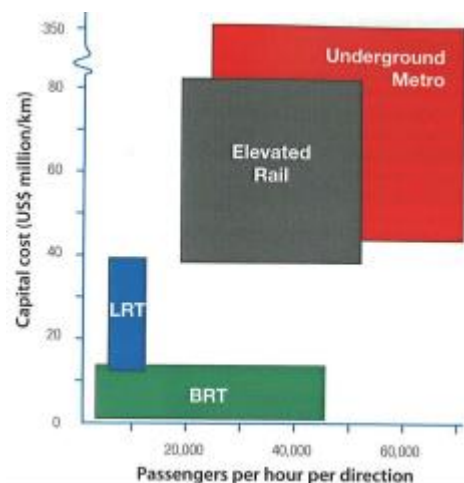


Figure 14 Transportation Capacity and Capital Cost



## &lt;Spotlight: Bus Rapid Transit Systems&gt;

*Many BRT systems use specially designed buses, called 'trunk' or 'bi-articulated' buses, that are long and divided into two or three compartments. Such buses can carry up to 140 passengers and travel in exclusive bus lanes, often with signal priorities at traffic lights. Since BRT uses or builds on existing road infrastructure, it is less expensive than light rail. In some cases where demand for mass transit is expected to grow but is not yet sufficient to justify the cost of light rail, BRT is an effective way to build ridership and shift driving commuters to the use mass transit, potentially paving the way for future light rail projects.*

*Successfully changing commuter behaviour to maximize ridership on new BRT systems depends to a large extent on system planning. Criteria for successful BRT systems include:*

- *Orientation (route alignment) to population centres and business/office centres,*
- *Accessibility to housing and offices along the route,*
- *Speed and efficiency of service (how fast to board, how fast to ride),*
- *Frequency of service at different times of day, and*
- *Comfort and safety for users (on vehicles and in associated facilities).*

### **iii) Introduction of Next-Generation Vehicles and Facilities**

One option for reducing CO<sub>2</sub> emissions in the transport sector is to shift the current gasoline-powered cars and motorbikes to low-carbon emitting vehicles, such as hybrid cars, electric cars, electric motorbikes and fuel cell cars that are currently being developed and promoted.

CO<sub>2</sub> emissions from an electric car can vary from almost zero to nearly as high as that from a gasoline-powered car, depending on the greenhouse intensity of the electricity. Fuel cell cars emit an extremely small amount of CO<sub>2</sub>. Figure 15 shows comparative levels of emissions from different vehicle types.

Given power supply conditions in low-carbon transport, the possibility that electric vehicles will be effective in reducing CO<sub>2</sub> emissions is quite high. However, electric vehicles face a number of challenges, among them restricted cruising range compared to gasoline vehicles and the need to establish new charging stations over a broad area.

However, this point makes the introduction of electric vehicles suitable in remote islands and remote areas, because the travel ranges of residents and number of charging stations needed in such areas are naturally limited, eliminating the above-mentioned disadvantages of electric vehicles, and because the price of gasoline generally tends to be higher than on the mainland.

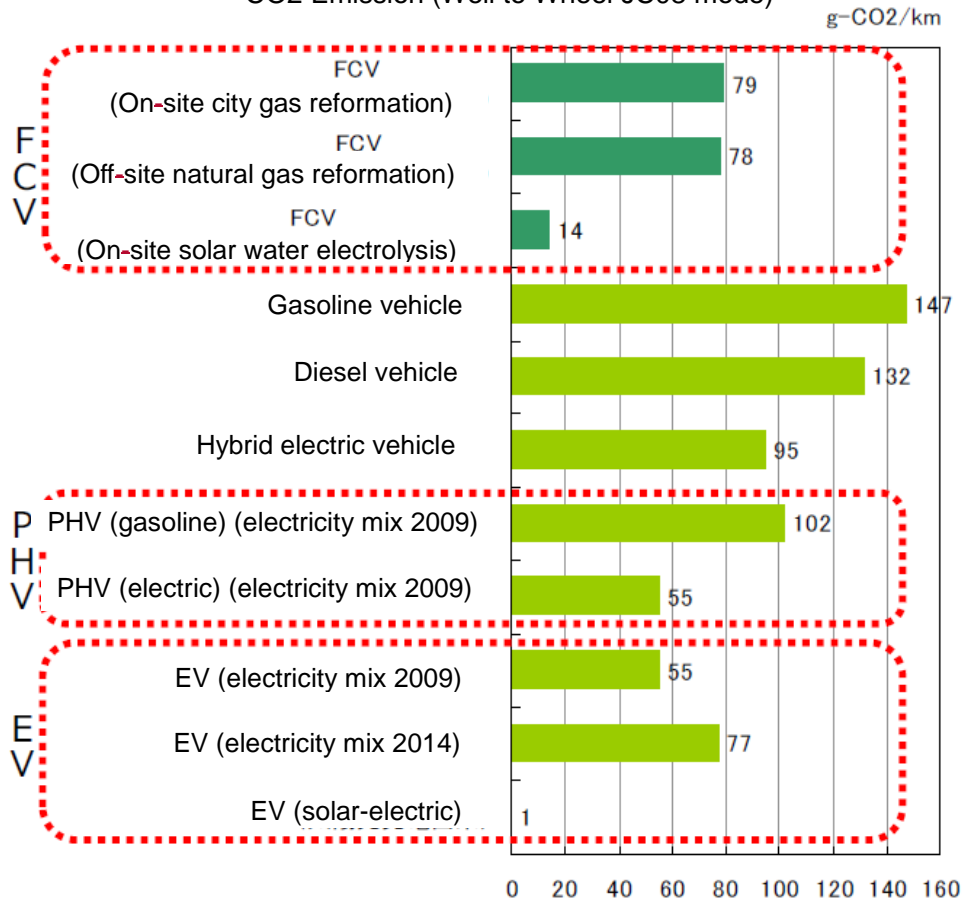
An effective option is the use of electric vehicles as rental cars in resort areas, where rental cars are a primary means of transport for tourists.

It is thought that the high cost of introducing low-carbon vehicles could inhibit their use. Measures to deal with this problem could include modifying existing vehicles (for example, converting them into electric vehicles or modifying them to run on biofuels) and applying high-solar reflectance paint to the roofs of buses.

Motorbikes are now widely used in Southeast Asian economies; the motorbike share of total road traffic in Viet Nam is almost 90%. While it is expected that the number of automobiles will increase

significantly along with economic growth in APEC economies, it is also anticipated that motorbikes will make up a high proportion of future vehicle use, and the development of electric motorbikes is considered imminent. Electric bicycles also offer a useful option in many urban areas.

Figure 15 Comparison of CO<sub>2</sub> Emissions by Type of Vehicle, Japan  
CO<sub>2</sub> Emission (Well to Wheel JC08 mode)



Comparison of CO<sub>2</sub> emission between gasoline cars and EVs electrically driven vehicle  
(Comparison of 1500cc-class vehicles)

Source: 'Hydrogen/Fuel-cell Strategy Roadmap' METI, Japan

In the case of resort islands, routine travel between the mainland and the island often involves ferries or other such vessels. Converting these vessels to run on biofuels will be effective in reducing carbon emissions. Other measures could include converting island fishing boats to run on biofuels and utilising natural sunlight on pleasure boats. Electric boats and small ferries (often with solar charging) are also emerging as practical options.

#### iv) Traffic Demand Management

Traffic demand management is a valuable element of low-carbon transport measures. This management includes parking management, mobility management, and 'park & ride' (P&R) systems. 'Park & ride' systems provide facilities for people to drive in a private car from home to the nearest train station or bus stop, park there and transfer to the public transit systems to travel to the centre of

the town. The systems that allow people to make connections from private cars to buses are called 'park and bus ride' (P&BR).

Improved management of road freight, including consolidating loads, controlling delivery times and scheduling, shifting to rail, possibly carrying some freight on public transport, etc. can reduce congestion, air pollution and carbon emissions. Modern telecommunications can increase the potential for smarter urban freight management.

The greatest benefit in reducing CO<sub>2</sub> emissions comes from supporting permanent changes in commuter habits with other tangible measures.

<APEC Workshop on Policies that Promote Energy Efficiency in Transport (WPPEET)>  
*The workshop, which was held in Singapore on 24-25 March 2009 provided a lively forum on a range of topics that covered fuel economy standards, operational efficiency programs, freight efficiency, mass transit, reducing road congestion, land use and urban planning, and the integration of transportation and energy policy.*  
<http://www.apec-esis.org/www/egeec/webnews.php?DomainID=17&NewsID=178>

## 5.2 Measures on Concerning Energy Supply

This section provides an overview of measures to reduce CO<sub>2</sub> emission concerning the energy supply of low-carbon town development.

### 5.2.1 Area Energy System

Area energy networks for low-carbon towns are classified into two patterns—a 'linked' type and 'independent' type—depending on the relevant network's relationship with the energy networks of neighbouring areas.

In the case of a 'linked'-type area energy network, it is important to build the network after taking into account the regional characteristics of not only the low-carbon town, but also neighbouring areas, the status of existing infrastructure, forecasts for energy and power demand and other considerations. Particularly in the case of remote islands, means for transporting equipment infrastructure needed by the network, means for connecting the network (e.g., laying of undersea cables, etc.) and other matters must be fully considered.

In the case of an 'independent'-type area energy network, it is assumed that the area will satisfy its own energy and power needs. Thus, the network must pay even greater attention to securing balance between energy/power supply and demand and providing backup power during times of disaster than is required for a 'linked' network.

The costs of existing energy supply should also be evaluated when considering introduction of area systems. For example, transporting diesel fuel to islands can be expensive, unreliable and polluting, while also adding to balance of payments economic impacts.

A typical area energy network is a system that efficiently supplies cold/hot water to consumers from a central plant at the district or regional level. The heat-energy demand may be for cooling, heating or hot water supply and is supplied via heat-energy supply conduits on a large scale.

These networks are possible in built-up urban areas around central transport nodes, such as train stations, where there is dense, mixed use of land combining business, commercial, hotels,

residential and cultural functions. These areas would usually contain a number of high-rise buildings and a variety of energy load patterns with some buildings having high energy loads.

It is possible to reduce CO<sub>2</sub> emission in a town through area-wide energy utilisation by purposefully constructing an 'energy centre' that integrates the heat demands of different buildings based on a network that allows for the cross supply of energy.

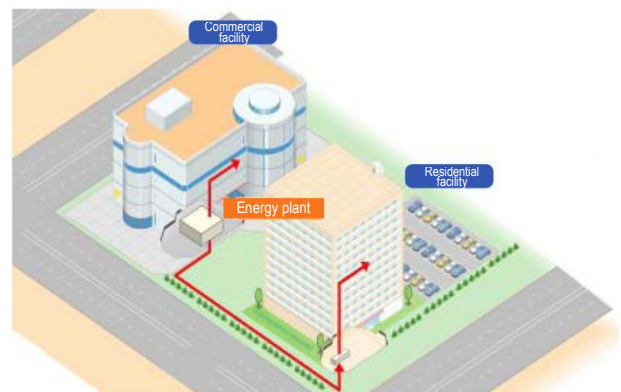
Area energy networks can be divided into three categories, depending on their scale.

- a District heating and cooling systems (DHC), covering a wide area (Figure 16)
- b Point heating and cooling systems, targeting multiple buildings in a single site (Figure 17)
- c Cross-supply of heat among multiple buildings

Figure 16 District Heating/Cooling Systems (DHC)



Figure 17 Point Heating/Cooling Systems



In recent years, co-generation (or CHP-combined heat and power) area energy networks that supply not only heat, but also electricity have also been appearing. Suburban residential and resort districts located in rural areas have relatively low energy consumption density per unit area compared to CBD. Thus, small- and medium-scale distributed power generation systems (co-generation), as well as small- and medium-scale power and heat networks that link the various forms of untapped energy and renewable energy to be mentioned below, are effective in such areas.

The emergence of energy storage systems (battery, thermal, etc.), improving the energy efficiency of buildings and equipment, declining costs of on-site energy generation and increasing potential for more sophisticated monitoring and management of energy use, are increasing the potential for area energy systems, including electricity micro-grids, to transform energy use. At the same time, they increase the importance of minimising distribution losses, standby losses and pumping energy to achieve net benefits relative to individual systems.

## 5.2.2 Use of Untapped Energy

### i) Untapped Energy Sources

In many towns and cities, waste heat is constantly produced by industrial facilities, power generation and plants that incinerate garbage and/or sewage sludge. However, these high volumes of waste heat are generally discarded, as there is little coordination with nearby energy demand. There are also other potential energy sources, such as river water, seawater, sewage water and sewage-treated water. These can be used as a heat source or a heat sink using a heat pump

technology, with the advantage that they vary less in temperature throughout the year than the ambient temperature.

These untapped energy sources could be developed at a regional level as part of low-carbon town development.

Heat pump technology efficiently transfers the heat energy contained in air or water in a source outside a building into cooling or heating required to keep interior thermal comfort; the energy demand for electricity or gas to run the heat pump is comparatively very low owing to the recent development of heat pump technology. Indeed, heat pumps capable of efficiently supplying steam have now been developed in Japan.

As was mentioned above, rural areas have relatively low energy consumption density. Thus, when using heat in such areas, it is important to fully study the use of waste heat from incineration plants, while taking into consideration the heat demand volume (demand density) or wastewater treatment plants, which require connection with DHC or other heat-supply facilities. This can make such systems more difficult to gain net benefits from than in the CBD.

#### **ii) Utilising Untapped Energy in Towns**

In large cities and towns, garbage/sewage sludge incineration plants and sewage pumping stations are often located near residential areas. These energy sources could be converted to energy supply for nearby buildings and houses, which would facilitate the cyclic use of energy at a regional level.

#### **iii) Managing Urban Development to Promote Untapped Energy Use**

An essential element of the effective use of untapped energy is to take all opportunities to link potential consumers with the energy source. Greenfield developments could intentionally site these waste treatment plants near urban areas with high energy loads. In existing urban areas, road maintenance and other infrastructure improvements provide an opportunity to establish the heat-energy supply conduits.

Linking untapped energy to existing power networks is not easy due to limitations arising from power supply conditions in each economy. Promoting the effective use of untapped energy requires the ability to formulate introduction plans that are tied to commercial power network studies at a higher planning stage, such as in the formulation of master plans.

#### **iv) Linking with Improvements to Urban Thermal Environment**

In the central built-up areas of large cities, the 'heat island' phenomenon is of serious concern, because of the volume of heat released into the atmosphere from rooftop cooling towers, road traffic, pedestrian pavements, surfaces of buildings, vehicle engines and air conditioning. In order to minimise the effect from solar radiation reaching surfaces, especially dark-coloured ones and roads, is converted into heat, which causes higher temperatures. Urban planning has to take into account the air ventilation of a town, greenery environment and the measures to apply high-solar reflectance paint for roads, sidewalks and the roofs of public transport vehicles (e.g., buses, trains and trams).

Water bodies, such as rivers and underground aquifers, can be effective absorbers of waste heat. This requires consultation with the administrators of the water body to make sure that it has sufficient

flow to avoid localised accumulation of heat in the waterway.

### **5.2.3 Use of Renewable Energy**

#### **i) Renewable Energy Sources**

The energy that exists in nature and that can be used repeatedly is called renewable energy. It includes solar energy (photovoltaic (PV) and solar heat usage), wind energy, biomass energy and geothermal energy. Renewable energy is widely available but is also unstable and dispersed. To make low-density energy effective for power and/or heat generation may require concentration, storage and distribution through energy conversion facilities, such as solar power plants. The declining cost of many renewable energy options, combined with improving energy efficiency, storage and energy management, means that simple solutions, such as PV, are increasingly viable. However, in high-density areas, adequate space and access to renewable energy are fundamental constraints.

Rural areas have lower land-use density compared to CBD's (making it easier for them to utilise large blocks of land) and can more easily access natural renewable sources. Thus, introducing mega solar power generation, large-scale wind power generation, hydropower generation (small-scale hydropower), and other systems that take full advantages of regional characteristics must be proactively considered in these areas. Here, medium- to long-term construction plans that take into account not only current energy efficiency, but also efficiency improvements to be gained from future technical innovation, should play an important role.

For cities, importing renewable energy from sources beyond the city can be a practical solution.

The introduction of heat pumps that utilise temperature differences in river water, oceans, lakes, marshes (example: as condensates to release heat) and soils, which have the potential as rich sources of natural energy that are closely tied to local communities, should be studied. Heat pump performance and efficiency is continuing to improve, so that heat pumps can save more energy and operate under more extreme conditions than in the past.

Moreover, possibilities for power generation by geothermal energy, ocean thermal energy, snow-ice heat and ocean waves should be studied.

The output of renewable energy (with the exceptions of geothermal and biomass sources) is influenced by time-variant weather conditions. Because of this, renewable energy presents the following problems: 1) inability to serve as a stable supply, 2) negative impacts on the transmission system arising from fluctuating output and 3) difficulty in adjusting the overall supply-demand balance.

Accordingly, additional measures will become necessary particularly when the share of renewable energy within the overall power source structure reaches a considerable level, for instance, making up for power generation instability by varying output of distributed power generation systems (co-generation), introducing DR (Demand Response) program or building batteries (or other storage such as pumped hydro or thermal storage) with power plants and transmission systems. Such measures will include controlling output fluctuations caused by varying sunlight or wind conditions and shifting surplus power generated during the night to peak daytime hours.

#### **ii) Using Renewable Energy in Towns**

While solar energy and geothermal energy can be utilised regardless of the regional characteristics,



there will be a higher potential for utilisation in suburban areas or middle/small-sized local towns rather than in the central areas of large towns. While renewable energy that is used for electricity generation will be developed widely, the deployment of renewable energy as a heat source depends on the regional heat requirement. In this sense, it is essential to foresee the future status of heat use and formulate a strategy for the use of heat in the future.

Improvement in heat pumps, including their use to produce steam for industry, potentially provides an efficient way of providing heat from electricity instead of gas, liquid or solid fuels.

< Renewable Energy for Urban Application in the APEC Region >

*The above report, which was commissioned by APEC EWG/EGNRET and published in January 2010, assessed best practices in renewable energy technologies, systems and resources in urban areas of APEC member economies. It includes examples in the residential, commercial, industrial and utility sectors. It is worthwhile to read, as it will provide insights about the approach to utilise renewable energy in the urban area, although it should be noted that recent cost reductions and innovations have increased the range of cost-effective opportunities available.*

[http://www.egnret.ewg.apec.org/reports/210\\_ewg\\_urban\\_application.pdf](http://www.egnret.ewg.apec.org/reports/210_ewg_urban_application.pdf)

### **iii) Managing Town Development to Promote Renewable Energy Use**

The benefits of renewable energies, such as solar and biomass, are considered to be relatively high in the local towns where the building density is relatively low. However, in these towns, there tend to be fewer opportunities to introduce renewable energy, such as in district redevelopment and replacement of buildings. Therefore, it will be necessary to capture the opportunities of refurbishment of government office buildings and hospitals etc. It will be also important to cooperate closely with town developers, who have plans for large-scale development.

### **iv) Linking Biomass Sources to Town Development**

Low-carbon town development near agricultural, forestry or livestock farming areas has the advantage of biomass energy. Effective use of biomass energy will require consolidation of the widely dispersed waste materials and establishment of a framework for the production of energy and use of energy locally.

Rural areas should be able to make effective use of biomass sources, such as agricultural waste, fisheries waste and forestry waste (e.g., timber from forest thinning, etc.), in the same way that food waste and urban waste resources generated in CBD are used.

## **5.2.4 Multi-Energy System**

There has been an increase in urban management risk due to widespread natural disasters in response to the progression of urbanisation around the world, and the constraints of energy supply and the vulnerability of centralised energy systems have become apparent. At the same time, with the expanded introduction of renewable energy, ensuring the quality of electricity, for example voltage and frequency, is becoming a major issue. In response to such conditions, it has become more necessary to combine and optimally utilise a variety of energy sources in consideration of regional characteristics (renewable energy, distributed energy and cogeneration) in order to disperse the risk of energy supply and reduce CO<sub>2</sub> emissions.

Distributed energy is a relative concept formulated in contrast with conventional large-scale, centralised energy and refers to energy that is distributed to many different regions on a relatively small scale, such as CHP and cogeneration. 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, activation of the regional economies, promotion of demand-side participation and reduction of load to the grid can also be expected to be side effects of distributed energy.

CHP and cogeneration are power generation systems using various fuels, such as natural gas, oil and LP gas, via methods that include engines, turbines and fuel cells, while recovering the waste heat generated during the process. The recovered waste 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.

The introduction of CHP and cogeneration can lessen the overall consumption of primary energy by reducing the amount of electricity supplied from the grid system while utilising waste heat for heating and hot-water supply.

### **5.3 Measures that Straddle Energy Demand and Supply**

#### **5.3.1 Energy Management Systems**

##### **i) Building-Level and Regional or District-Level Energy Management Systems**

###### **a) Building-Level Energy Management Systems**

Building-level energy management systems prevent unnecessary energy use by automatically adjusting the operation of equipment in a building. For example, this kind of system turns off lights in unused rooms and controls the air-conditioners and lighting in response to variations in room temperature and light intensity. These systems can also improve monitoring of equipment performance and usage, so that faulty equipment and inefficient practices can be identified and addressed. Depending on the type of the targeted buildings, there are different forms of building-level energy management systems: building energy management systems (BEMS), home energy management systems (HEMS) and factory energy management systems (FEMS). Their introduction can result in significant reductions of energy use.

###### **b) Regional or District-Level Energy Management Systems**

Energy management systems at the regional or district level will prevent unnecessary energy use in the central heat-supply plants. These systems use surveillance and control systems and high-speed communication networks to monitor and control plant operation. This energy management system is called AEMS (Area Energy Management System). AEMS may be regarded as an area-wide energy use based on IT technology, and this system has already been put to practical use.

##### **ii) Smart Grid Systems**

The smart grid system is a new concept of electricity transmission/distribution network that controls and optimises the flow of electricity from both the demand and supply sides. These systems require the installation of a 'smart meter' on the demand side.

Conventional electricity transmission is designed for peak demand, which results in electricity waste. In addition, outdated and aging transmission/distribution lines are vulnerable to overload and natural disasters and can be difficult to repair after an outage. Smart grid systems have been proposed as the next-generation transmission/distribution systems that can maximise efficiency, while facilitating the introduction of electricity from distributed renewable sources, use of storage and smart energy management systems.

As well as offering these low-carbon benefits, it is noted that smart grids rely on advanced communication systems, which could be vulnerable to tampering or computer virus infection, and so need to be carefully safeguarded.

Smart grid systems are different from one economy to another, due to factors such as electricity market structure and stability of the power transmission/distribution network. Smart grid systems have following potential benefits:

1. Reduction of electricity consumption can be expected in terms of demand through measuring and visualising the electricity consumption with the smart meter and improved management using manual or automated control. It is also possible to shift peak demand by restraining consumption during peak electricity generation or by utilising local energy storage.
2. Stability of electricity supply and prevention of blackouts will be improved by the safety-control equipment installed on the electricity transmission/distribution network. This reduces the social disturbances caused by blackouts, providing economic benefits for the whole society.
3. Electricity generated from solar and wind energy can be highly variable in volume, depending on the season or time of the day. If renewable power is connected to the power transmission/distribution network, it may result in voltage variation for the network. The smart grid systems avoid this problem by matching the supply from the utilities with the demand of the consumers and, increasingly, by utilising storage.
4. Under the smart grid systems, it is expected that surplus electricity generated by renewable energy can be controlled by temporarily storing and discharging electricity using batteries or other storage technologies connected to the grid (e.g. thermal storage, pumped hydro). In the future, it may be possible to adjust the demand-supply balance in the whole electricity network, making efficient use of batteries mounted on 'plug-in' type electric cars and hybrid vehicles stationed at households.

Overall, smart grid systems seek to reduce the wasteful electricity consumption on the consumer side and promote the introduction of renewable energy in terms of energy supply. In many towns and cities in APEC member economies, smart grid system demonstration projects are under way, supporting innovation not only in the energy area, but also in the wider town infrastructure, including buildings, traffic system design and management. The goals of these projects address the different socio-economic conditions of their respective economies and regions.

**<APEC Smart Grid Initiative>**

*The APEC Smart Grid Initiative (ASGI), established in 2010 by APEC's Energy Working Group (EWG), evaluates the potential use of smart grids and grid management technologies, energy efficiency, renewable energy technologies and intelligent controls to link customers to the grid and enhance the use of renewable energy and energy efficient buildings, appliances and equipment. The goal of the initiative is to create best practices in operation (through workshops and actual testing), as well as interoperability standards to create highly efficient systems that are easily replicable.*

<http://www.egnret.ewg.apec.org/meetings/egnret36/E3-APEC%20Smart%20Grid%20Initiativ>

Future energy systems will be 'smart' at all levels. Regarding energy supply, it is expected that town energy systems will combine large-scale integrated power generation from sources, such as thermal, hydroelectric and nuclear, a large number of CHP, and small-scale renewable-energy power generation in individual households. In terms of energy demand, there will be energy management systems in place at all levels: domestic, commercial, civic, and area-wide. Energy storage could appear at many points in the smart grid.

Smart energy systems seek to optimise the total energy use by coordinating all energy management systems in a single district. It is also possible to optimise the total energy supply and consumption by combining not only electrical systems, but also heat supply systems, which use cogeneration and thermal storage equipment.

Another type of smart energy system aims to connect energy systems with water circulation systems by using water as a heat storage media and adjusting the operation of water treatment facilities to absorb variation in energy load.

Smart energy systems are likely to be a main approach to future low-carbon town development, even if not immediately applicable to all current projects.

Smart energy systems are optimised networks that integrate heat, power and other energy with ICT. They are expected to be used more effectively through their application in CBD and other areas that have relatively high energy consumption density. When planning their use in rural areas, it is important to design smart energy systems, taking into consideration demand volume (demand density) for each energy type (power or heat).

## **5.4 Measures for Environment and Resources**

### **5.4.1 Greenery**

#### **i) Effect of Greenery**

##### **a) The Heat Island Phenomenon**

Greenery is an effective way to create eco-friendly urban environments, absorb CO<sub>2</sub> and mitigate the heat island phenomenon (see chapter 6 for a description of CO<sub>2</sub> absorption).

The heat island effect is found mainly in urban areas where urban surfaces, such as concrete and asphalt pavements, and building surfaces replace permeable moist open land and vegetation. The urban surfaces store heat from the sun or heat exhaust from buildings and vehicles, causing a one to

three-degree difference for urban heat islands compared with surrounding areas.

Urban air temperature has dramatically increased over the past 100 years compared with non-urban global levels. In Japan, the mean air temperature in Tokyo has increased by over two degrees, comparatively the average temperature increase for the whole of Japan is around 0.7 degrees.

Urban air temperature has increased continuously alongside global warming. This has especially been the case for Asian urban cities, which have rapidly urbanised in recent years. The heat island phenomenon also creates micro-climates. This has the potential to create secondary problems, such as increased energy use from use of air conditioning in buildings, ecosystems degradation and new pathogens from increased temperatures.

Figure 16 Increase of Annual Mean Temperature

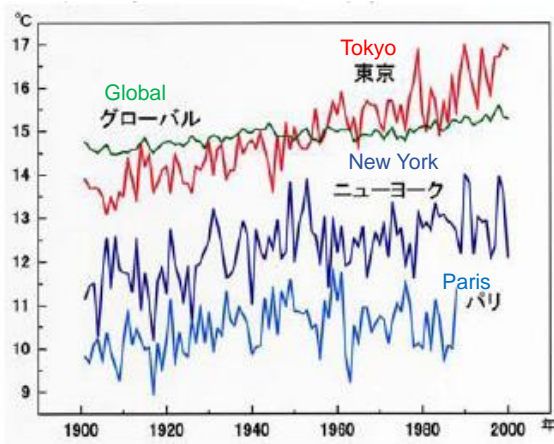


Figure 17 Spread of Heat Island Area in Tokyo Metropolitan (from 1891 to 1999)

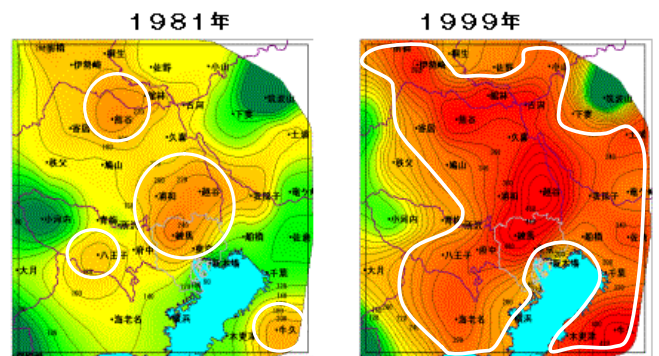


Figure 18 Distribution of Surface Temperature around Greenery Planning Area (12:00, August, Tokyo)

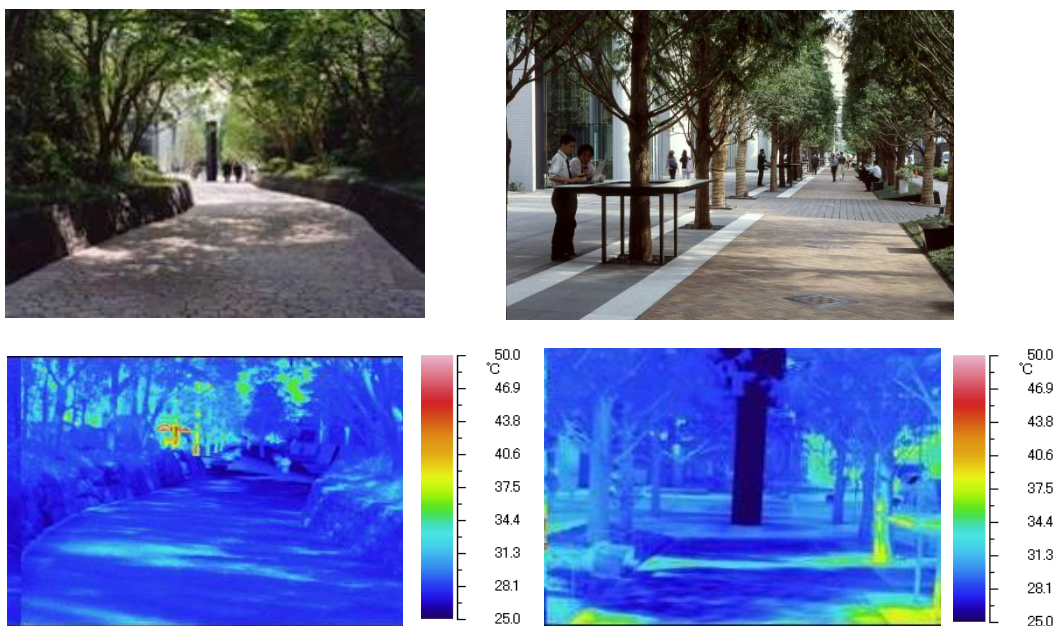
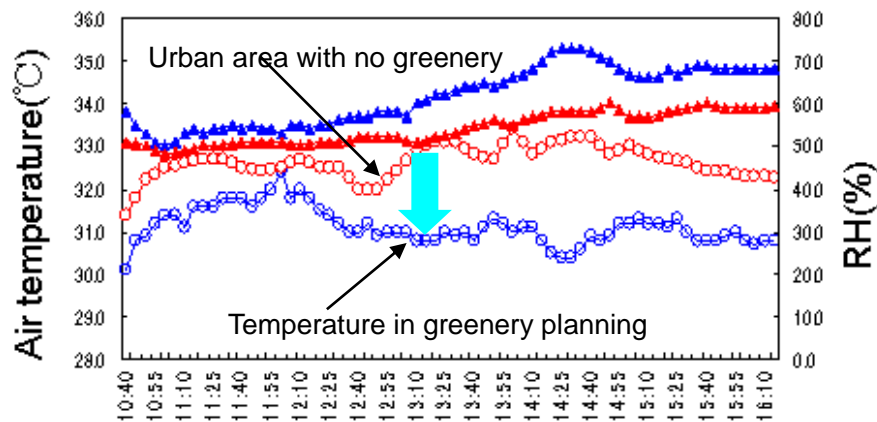


Figure 19 Mitigation Effect of Air Temperature by Greenery Area (12:00, September, Tokyo, 2005)



#### b) How to mitigate the heat island phenomenon with greenery (Improving urban surfaces)

Greenery is an excellent way to control thermal environments. Tree leaves can help to decrease air temperature by around one degree due to evaporation occurring on the surface of leaves. It is important to enhance greenery in developed areas by promoting green building practices, such as adopting green roofs and walls.

The type of greenery used is also important as tall trees with big crowns are not only more effective at mitigating air temperatures around the crown, but also work to decrease the surface temperature of the ground surface under and around the trees.

It is important to select appropriate plants and install effective irrigation and management systems so that they remain healthy.

#### ii) Greenery as Carbon Absorption Measure

Additionally, greenery works as a useful carbon absorption mechanism, which can contribute to establishing a LCMT by counteracting, in part, the impact of deforestation on CO<sub>2</sub> absorption rates. Forests are carbon absorption sites in suburban and rural areas. Hence, increasing tall tree planting in urban areas is a comprehensive low-carbon measure for a LCMT.

The strength of carbon absorption would be comparatively ranked as follows:

Tall tree (Ex: zelkova, around 10 – 20 years) > Mid and low tree > turf (ground surface green)

### 5.4.2 Water Management

#### i) What is Water Management?

Water management in urban areas roughly plays two roles: water management for supplying water used in human activities and water management for collecting and treating waste water and rainwater to return them to the natural world or reuse for irrigation or cleaning purposes.

a) Water Supply

A water supply is a system for supplying the required amounts of safe water according to the demand in an urban area. While water is used for daily life in domestic, municipal, industrial, and agricultural applications, water supply systems mainly supply domestic and municipal water.

The essential requirements for water supply to play this role are the quantity, quality and pressure of water, which are called the three requirements of a water supply.

b) Sewerage

Sewerage is a facility for collecting and treating wastewater to return it to the natural world. The water, taken in clean, is used in human activities. Then, it is collected as sewage, treated at sewage treatment plants and returned to the hydrological cycle through waterways or re-used for various purposes depending on the quality and volume of water and local community attitudes.

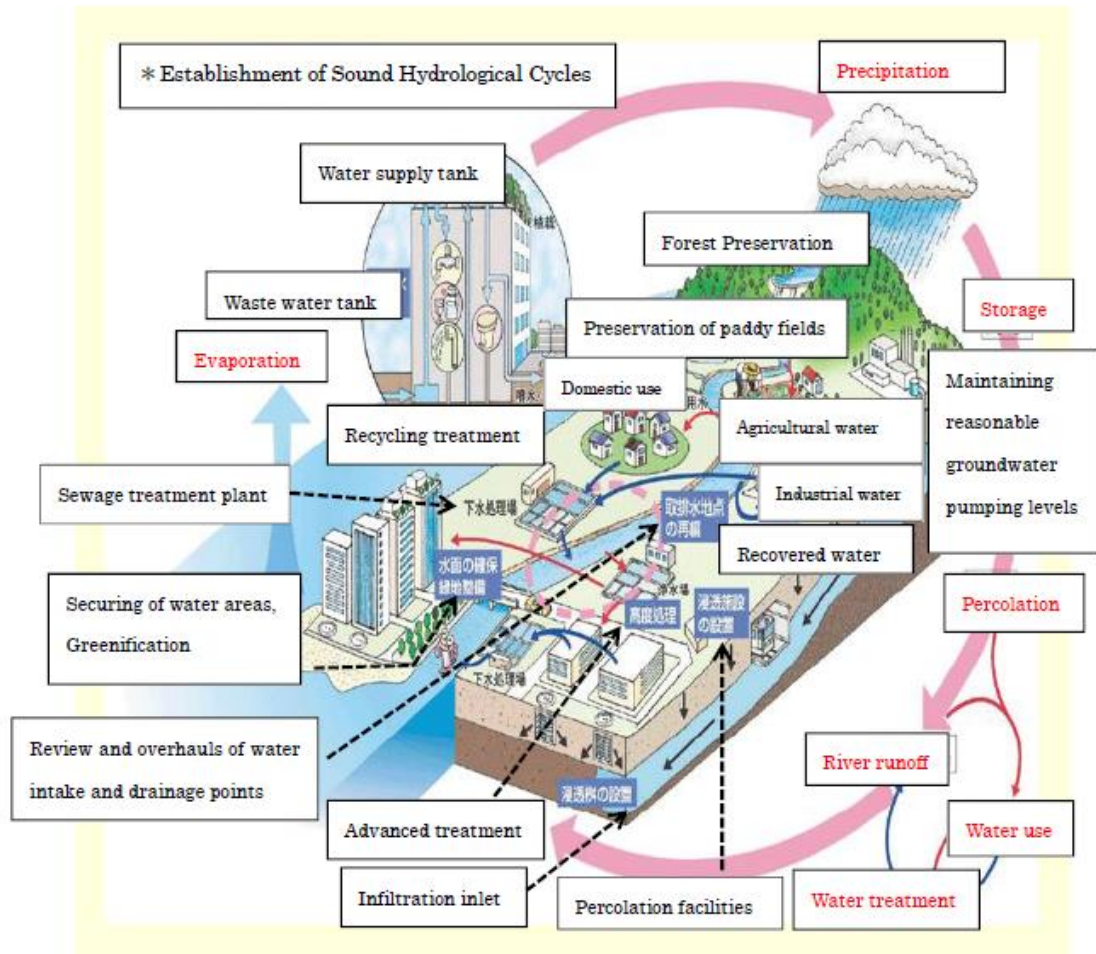
**ii) Contribution of the Water Management to Low-Carbon Town Plans**

To ensure sustainable water usage, it is important to preserve reservoir areas and reproduce hydrological cycles through low-carbon and cyclic use of water resources by, for example, reducing emissions of greenhouse effect gases and making effective use of energy obtained from water resources.

a) Contribution of Hydrological Cycles (Water Management) to a Low-carbon Town

To contribute to the maintenance of low-carbon towns, measures will be taken, such as the use of potential and natural energy, development and incorporation of energy saving technologies, and efficient operation of facilities and systems. In addition, measures for avoiding waste, including measures against leakage and water saving, are effective.

Figure 20 Conceptual Rendering of the Construction of an Establishment of Hydrological Cycles



(Source) Drawn by Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism

#### (1) Water Supply Infrastructure Based on Gravity

When a new facility is set up or an existing facility is upgraded, upstream intake can be introduced (or a shift to it can be made) to construct a gravity-flow water distribution system using gravity-based on potential energy. (The ultimate low-carbon implementation is to obtain potable raw water based on gravity flows.)

Considerations:

- ✓ In arranging water intake in the most appropriate upstream area, the current regionalization may limit the effective use of water resources. It is important to select intake points across a broader range.
- ✓ Not only water quantity and quality, but also various potential uses of water and location, must be taken into account in selecting intake areas.
- ✓ Because upsized and integrated facilities present safety problems under emergency conditions, it is essential to ensure sufficient safety in considering the scales and locations of these systems (balance between centralization and decentralization)



## (2) Use of Small-scale Hydroelectric Power Generation Based on a Low Flow Rate and/or Small Drops at Rivers, Water Supply and Sewerage

### Considerations

- ✓ Small scale hydroelectric power generation may not be cost-effective, but economies of scale in modular production and installation can cut costs. Also, if equipment feeds electricity to the grid at times of peak prices, or feeds power to end users instead of competing with much lower wholesale electricity prices, the economics may vary. This should be framed in a more neutral way.

Considerations associated with sewerage capabilities and waste water treatment systems:

## (3) Biogasification and Conversion of Sludge to Fuel

### Considerations:

- ✓ Depending on the life-cycle environment and sewage piping, sewage sludge includes only a small amount of organic substances (energy). In this case, gasification or conversion fuel may not generate sufficient energy.
- ✓ In some areas where agriculture is dominant, composting may be the most effective means rather than gasification and conversion to fuel.
- ✓ It is necessary to consider to treat sludge from household and industry together to reduce greenhouse gases in treating sewage sludge and reuse of energy.
- ✓ Combining sewage sludge with other organic wastes sourced locally can improve the economics of biogas production or pyrolysis.

## (4) Use of Treated Sewage Effluent

Treated sewage effluent can be used as agricultural, industrial and environmental water.

### Considerations:

- ✓ The use of treated sewage effluent has problems in terms of water quality/safety and energy saving.

## (5) Use of Space of Water Supply and Sewerage Facilities

Space of facilities is used to make use of renewable energy including photovoltaic power generation.

## (6) Use of Grey Water in Commercial Buildings and Other Facilities

Relatively clean water used in buildings is treated so that it can be reused as grey water for rest rooms and irrigation of vegetation (the use of rainwater and reuse of miscellaneous drainage are evaluation targets of CASBEE).

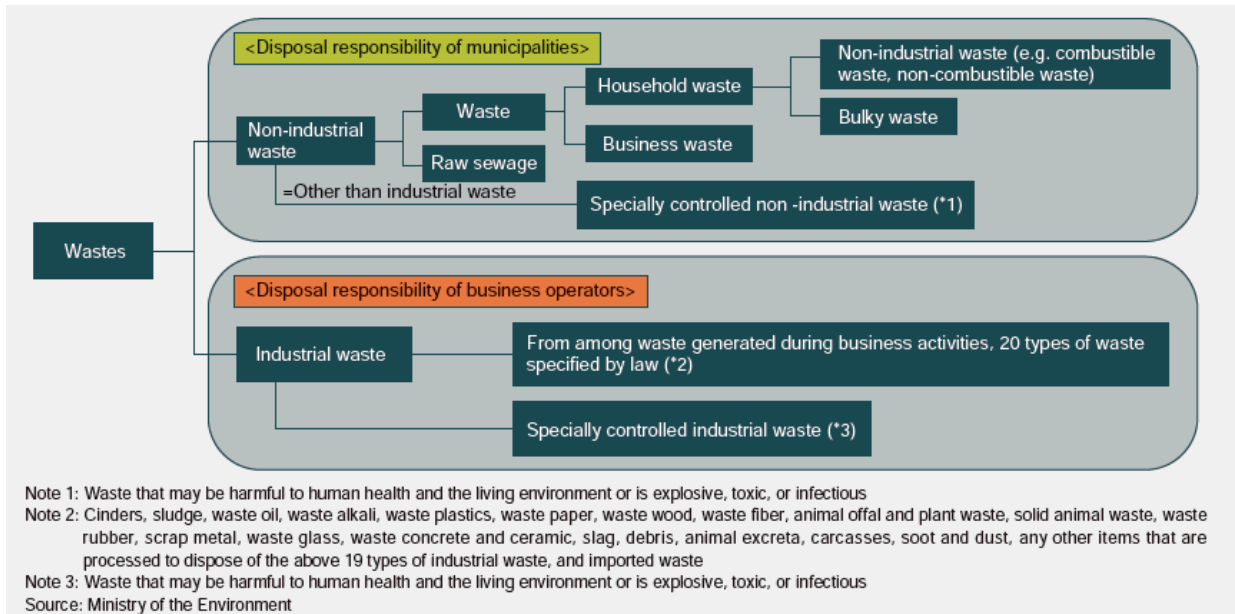
### **5.4.3 Waste Management**

#### **i) What is Waste?**

Waste is defined as unwanted materials or items that are no longer used personally or that are not delivered for value, and such materials or items can be described as, for example, garbage, bulky

waste, burnt residue, polluted mud, and feculence, either in solid or liquid form. In Japan, it is classified as shown in Figure 21 in accordance with the Waste Disposal and Public Cleansing Act.

Figure 21 Segregation of Wastes in Japan<sup>1</sup>



Source: Ministry of Environment, Japan

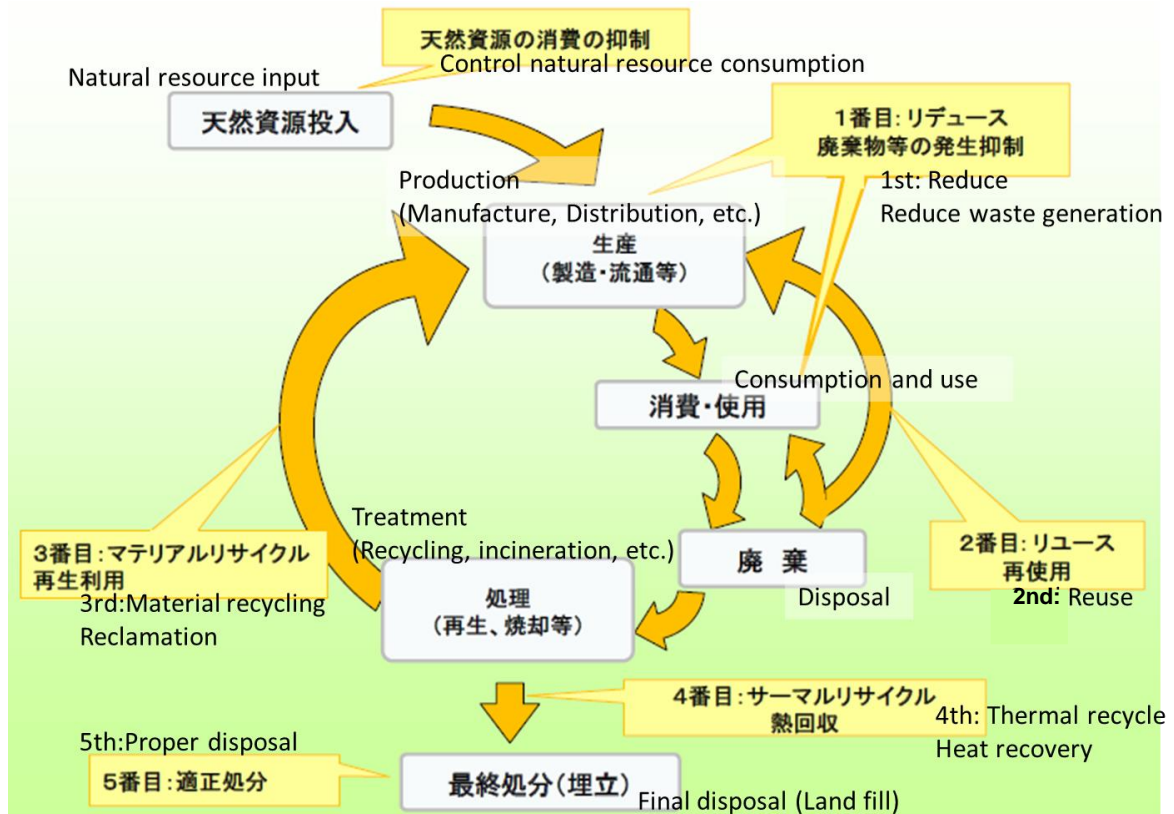
When developing a town, it is important to map out a town plan considering what measures should be taken to treat waste (non-industrial waste classified as waste generated in business operations or household waste), which will increase in pace with the expansion of the population.

<sup>1</sup>Each economy uses different terms or definitions for waste classification (e.g. categorize industrial waste into 'Hazardous industrial

## ii) Realisation of a Low-Carbon Town by 3R Activities

We need to reduce the environmental load from waste treatment as a whole. Reducing the volume of discharged waste by means of the 3R activities (Reduce, Reuse and Recycling) and choosing appropriate methods of waste treatment are two important elements of the reduction of greenhouse gas emissions from waste treatment. Some waste management strategies now include 'recover energy' as a 4<sup>th</sup> 'R'.

Figure 22 3Rs and Recycling-Oriented Society



Source: Ministry of Environment, Japan

A conceptual diagram of 3Rs and recycling-oriented society is shown in Figure 22. A recycling-oriented society is a society where the consumption of natural resources is controlled and the environmental load is reduced to the maximum extent possible. It can be realised by ensuring the reduction instances when products become waste in the first place, the proper use of generated waste as resources in the second use, and the appropriate disposal of what cannot be reused lastly. To realise a recycling-oriented society, the 3Rs need to be promoted

To establish a recycling-oriented society through the promotion of the 3Rs in Asia, the Regional 3R Forum in Asia was established in November 2009 based on a proposal by Japan. The aims of the activities are to promote high-level political dialog regarding the 3Rs, implement 3R-related projects, share institutional and technological information that may be helpful for 3R promotion and establish a network of parties concerned.

While organic waste can be used to produce useful energy, metals, plastics and other non-organic wastes contain valuable resources. Recovery of them can avoid production of virgin materials, in many cases saving a large proportion of the energy that would have been used. For example, recycling aluminium can avoid around 90% of the energy used to produce virgin aluminium. The 'ores' available from wastes and landfills are rich in valuable materials. Research is progressing to develop methods to recover all these resources.

### **iii) Concrete Efforts to Realise Recycling-Oriented Society and Low-Carbon Town**

By promoting the 3Rs of waste, the volume of waste incineration<sup>2</sup> and direct landfilling is reduced. At the same time, power generation and utilisation of the heat exhausted from the incineration of waste and the use of biomass energy is promoted in Japan to reduce the consumption of fossil resources. It is executed by means of subsidies from the government for the facilities converting waste to energy and the ones where methane is collected from organic waste with high levels of efficiency.<sup>3</sup>

#### a) Example: Waste to Energy

Waste to energy is a generic name for the electricity generation from waste, although useful heat can also be produced. In many cases, it is specifically used for the system where steam is produced in a boiler using high-temperature combustion gas generated from the incineration of waste, and the turbine of a power generator is rotated by the steam to generate electricity.<sup>4</sup> In a broad sense, the waste to energy concept also includes landfill gas utilisation, which is commercially used in the U.S. and other economies. For example, methane gas retrieved from organic wastes in landfill can be utilised in the power-generating process.

#### Strengths of waste to energy<sup>4</sup>

- i. Fossil fuel consumption and CO<sub>2</sub> generation are reduced, as it uses the energy generated by waste incineration.
- ii. Electricity supply is more stable than other new energies.
- iii. The facility is located in or near a city and therefore it is a distributed power supply directly connected to the area of demand, though the scale is small.

#### Weaknesses of waste to energy<sup>4</sup>

- i. The temperature of the steam in a boiler must be kept lower than an ordinary thermal power plant. Therefore, the power generation efficiency is low.
- ii. The power generation efficiency of small-scale facilities (under 100 ton/d) is even lower. The effect of the introduction of waste to energy is undermined unless the waste heat can also be utilised.
- iii. Long-term storage and stable combustion are more difficult than such fuels as natural gas and coal.

<sup>2</sup>It is important to control dioxin in incineration process both in exhaust gas and ash residual.

<sup>3</sup>MOE: 'Annual Report on the Environment, the Sound Material-Cycle Society and the Biodiversity in Japan', 2014

<sup>4</sup>Y.Suzuki: 'Current Situation and Issues of Waste Power Generation', *Reference*, May 2014 (in Japanese)

b) Example: Utilisation of Waste Biomass<sup>5</sup>

Direct landfill of waste biomass, including woodchips, on a final disposal site must be stopped at the earliest opportunity, because it produces methane gas that has a high global warming effect. It is necessary to recycle such resources in a way suitable for the characteristics of the region. Food waste composting is one of the more mature and practical recycle ways to turn waste into fertilizer. Waste biomass is an organic resource derived from an animal or plant from which fossil resources are excluded. There are a variety of types: waste, such as livestock excrement, sewage sludge, and kitchen waste; non-edible parts of farm products, such as rice straw; unused resources, such as timber from forest thinning; resource crops, such as sorghum; and algae. To make the waste biomass useful in our daily lives, technologies to convert it into heat, gas, fuel or chemical substances are necessary. The types of the technologies vary from simple ones, such as direct combustion, to sophisticated ones, such as saccharification, fermentation, gasification and re-synthesis. Their attained levels are also varied from a basic research phase to the subsequent validation phase and practical application phase.

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<sup>5</sup>MAFF: 'Biomass Commercialization Strategy', 2012, (in Japanese)

#### 5.4.4 Pollution

Urbanisation, a population concentration in urban areas as a result of developments in industry, began in the 19th century, and in recent years, rapid urbanisation has been taking place in APEC economies. Energy consumption has increased as a result of mass consumption by residents in urban areas, as well as high-density social and economic activities, resulting in increasing CO<sub>2</sub> emissions. At the same time, typical environmental pollution resulting from the urban lifestyle (urban-type environmental pollution), such as air pollution caused by automobile exhaust and inefficient cooking, water pollution caused by domestic wastewater, and soil contamination caused by improper processing of household and business waste, are becoming significant problems.

Environmental pollution can also be caused by exhaust gas, wastewater and other waste discharged from factories in urban areas, and this environmental pollution is called industrial-type environment pollution. Depending on the socioeconomic development level of an economy, the extent to which the urban-type and industrial-type environmental pollution causes environmental pollution in the cities varies. In developed economies, the relocation of factories out of urban areas has greatly reduced the proportion of industrial-type urban environment pollution. However, soil contamination in factory sites has become apparent as a result of the relocation, and there have been cases where soil contamination became an impediment to the re-development of the sites.

In developing economies, there are many factories in urban areas, and there is a combination of urban-type and industry-type environmental pollution. The industry-type environmental pollution has been decreased by strong initiatives taken by governments and local authorities, but policies to address urban-type environmental pollution have been lagging, causing an increase in the proportion of urban-type environmental pollution in certain cities. This is partially due to the fact that sources of industrial-type environmental pollution are stationary sources, such as factories and power plants, whereas sources of urban-type environmental pollution are individually small, but widely dispersed, and sometimes it is not enough to regulate the sources of pollution.

Global population growth and economic development will create excessive loads on the global environment causing global warming. Urbanisation will create excessive loads on urban environment, causing urban environmental pollution. Although both are threatening the sustainable development of society, urban environmental pollution can directly damage human health and can, therefore, be considered as a more serious issue in the short term. In addition, urban-type air pollution is different from industrial-type environmental pollution as individuals can be both the party at fault and the sufferers. It is necessary to reform the patterns of consumption, technologies used and lifestyle of individuals in order to overcome the issue.

Increased urbanisation resulting from economic development is a phenomenon seen in every economy. Cities have strong social, economic and cultural activities that maximise the benefits of the integration of various urban functions. In recent years, there have been examples of economies positioning 'urbanisation' itself as a powerful driving force behind the economy's growth. Only when cities have overcome the negative aspects of urban environmental pollution and have ensured safety and security, ease of living and comfort, can we say that they have truly been developed. To this end, efforts to address urban environmental pollution are becoming increasingly important.

### **i) Air Pollution**

The major air pollutants are nitrogen oxides (NOX), sulphur oxides (SOX), suspended particulate materials (SPMs) and photochemical oxidants (OX). All NOX, SOX and SPMs may damage the respiratory tract. While SPMs refer to particles of diameter 10 µm or less, those particles with an even smaller diameter or 2.5 µm or less often cause asthma and bronchitis by entering deep into the lungs. It is said SPMs can also cause lung cancer. OX causes sore eyes and nausea, etc.

The sources of NOX include thermal power plants, factories, offices, inefficient cooking, open fires and motor vehicles. Sometimes NOX are formed when fuels, such as oil, are burned, and the nitrogen contained in these fuels reacts with oxygen in the air. While a large percentage of NOX emissions are from stationary industrial sources, in urban areas, where there is a concentration of service functions, the proportion of these emissions from automobile traffic is higher. SOX are formed when the sulphur contained in fuels reacts with oxygen in the air, and their sources are the same as NOX. However, due to decreases in the sulphur content of automobile fuel, the majority of SOX now come from thermal power plants, factories, etc.

SPMs are generated by soot and dust emitted from factories, as well as black smoke, etc. in the exhaust gas from diesel vehicles and from open fires. SPMs cause smog, which is currently a significant problem in China. SPMs are classified into primary particles, which are discharged directly into the atmosphere from the source, and secondary particles, which are discharged as gaseous substances (SOX, NOX, volatile organic compounds (VOC), etc.) and transformed into particles in the air through photochemical reactions. SPMs are made through photochemical reactions that occur when NOX, VOC, etc. are released in the atmosphere and exposed to the ultraviolet rays of the sun.

Efforts to prevent air pollution in cities begin with setting emission reduction targets for air pollutants and determining emission standards for each type of pollutant. As described above, since air pollutants are also discharged from factories in urban areas, emission reduction targets must be set by region. In addition, in order to reduce the emission of industrial-type pollutants, efforts must be taken by individual pollution sources. Therefore, factories, power plants, etc., should be required to make air pollution prevention plans. When doing so, they should also be requested to set emission reduction targets for each type and scale of their facilities.

The monitoring of air pollution is a particularly important role of the municipal government. Through monitoring, it becomes possible to analyse the condition of discharged air pollutants and the causes of air pollution in detail. The monitoring location, frequency and related limits for each type of pollutants should be specified in official environmental monitoring and audit manuals. Based on the monitoring, some specific regulations may be tightened if needed. Furthermore, management procedures that can reduce identified pollutants to levels below the stipulated limits should be specified. However, except for the largest cities (e.g. in Hong Kong), such monitoring has not yet been implemented in most cities. It is additionally important to publish monitoring results and create programs to protect the health of citizens, such as issuing a pollution alert. There can be a wide range of measures for air pollution prevention. It is also important to ensure human resources, such as government officials and specialists, are available and trained for the long-term measures.

## **ii) Water Pollution**

The major water pollutants are heavy metals, such as cadmium and lead, organic mercury, and volatile organic compounds. The sources of these pollutants are mainly drainage water and industrial waste from factories in the chemical and metal industries. Heavy metals from ground water used for drinking can also be a significant source of human consumption. These contaminants cannot be degraded naturally, and can cause serious health problems if they accumulate in the human body.

In addition, organic substances contained in the wastewater from households, food industry, and pulp and paper industry are also regarded as water pollutants. When these organic substances are discharged into rivers in quantities above their natural purification capability, a large amount of dissolved oxygen is consumed in order to degrade them. The depletion of oxygen in the water causes environmental pollution, such as the unpleasant odour of ammonia or hydrogen sulphide. The degree of organic pollution is represented by indicators, such as the amount of oxygen dissolved in the water (DO), and the oxygen consumed when organic substances are oxidised and decomposed by aerobic microorganisms (BOD).

In many cities, organic pollution is becoming mostly composed of urban-type environmental pollution rather than industry-type environmental pollution due to the fact that sewage treatment infrastructure cannot account for rapid urban development. If large volumes of untreated sewage continue to be discharged into rivers, it can threaten the safety of citizens, and the water shortage may negatively impact the economic growth.

As in the case of air pollution prevention, it is important to establish emission reduction targets and emission standards, and to regularly monitor discharge conditions as part of efforts to prevent water pollution in cities. Also, the retention and training of staff is similarly important.

## **iii) Soil Pollution**

Urban soil contaminants include radon, benzene, cyanide, lead, arsenic, chromium and mercury that penetrate the underground of factory sites. While normally these contaminants are undetectable since they penetrate the ground deeply, their damage becomes apparent after the relocation of the factory or the source of pollution. These soil pollutants tend to remain in their deposition location without diffusion due to adsorption. The health of local residents may be at risk due to the diffusion of dust from contaminated soil and penetration of groundwater. Soil pollution may also be caused by improper handling of waste.

When making policies to address soil pollution, it is important to take preventative measures to ensure new soil pollution does not occur in the future and to establish appropriate framework to supervise and process the treatment of contaminated soil by industry professionals.

## **5.5 Governance**

### **5.5.1 Policy Framework**

Policy measures, such as low-carbon transport and low-carbon construction, will promote the efficient use of energy and eventually build a low-carbon society. Since it is difficult for private sectors to enact these efforts solely, proactive efforts and leadership of the government are necessary. For



cities, it is often necessary to work cooperatively with governments at other levels. This may be necessary because regional and national governments have the necessary regulatory powers and policy roles, as well as finances to aid in these processes.

#### **i) Low-Carbon Policy / Planning Budget**

In order to promote a variety of low-carbon town initiatives at each regional, national and local level, it is important to develop and promote the 'software', such as laws, regulations, policies, systems, and public-private partnerships in addition to the technological 'hardware'. Therefore, the establishment of administrative structure for implementing the initiatives is necessary.

To be precise, the government efforts should include planning low-carbon urban development measures, developing a project implementation plan, and ensuring the budget and resources. For example, the government can create their own low-carbon guidebooks and climate change policies, or supervise developers to create them.

#### **ii) Sustainability Efforts**

In order to make low-carbon towns sustainable, while ensuring citizens' safety and considering the environment, the government should only allow development that has low impact on the environment and does not cause blackouts or other failures resulting from natural disasters, etc.

For example, the measures include making plans in order to continue daily life and business activities even in the event of a disaster. These are known as Life Continuity Plans (LCP) and Business Continuity Plans (BCP).

#### **iii) Low Impact Development**

The government should create regulations taking into account the terrain characteristics and alterations of the terrain for the sustainability of low-carbon towns.

In the development activities, conservation of natural terrain and restriction on artificial modifications (e.g. development activities, such as installation of the retaining walls, that interrupt continuous landscape) to a certain level should be regulated by the government.

### **5.5.2 Education & Management**

#### **i) Education**

When developing low-carbon towns, education and awareness campaigns are important so that citizens can recognise the importance of low-carbon activities and deepen their understanding. In advanced low-carbon towns, various local stakeholders work individually/together to promote the low-carbon activities without too much dependence on the government's leadership. Low-carbon activities can begin with small changes in daily actions, such as turning off unnecessary lights, setting the air-conditioning at a proper temperature and ceasing littering. Additionally, if employers of business vehicle drivers require them to drive in an environmentally friendly manner, prevention of air pollution and reduction in accidents and fuel consumption can be achieved while saving corporate costs. It is effective for the government and developers in the private sector to approach and work together with various stakeholders including local residents, companies and educational institutions.

Training tradespeople, professionals and sales people to understand low-carbon actions and

encourage them in their work is important. At the same time, if individuals do not call for products and services with low-carbon outcomes, businesses will be less likely to provide appropriate offerings. Children must also be educated to prefer a low-carbon future and understand what is involved.

## **ii) Management**

Low-carbon activities can also be developed by area management organisations, such as community councils and neighbourhood associations, in addition to the government and private developers. There are many examples where involving local residents from the early planning stage and the stakeholder involvement brought a success in spreading the low-carbon activities throughout a town. Additionally, it is desirable for organisations rooted in the region to share information using their community networks and continue low-carbon activities. If the regions can improve their problem-solving abilities and attractiveness through such low-carbon activities, low-carbon towns are sure to spread both domestically and abroad.

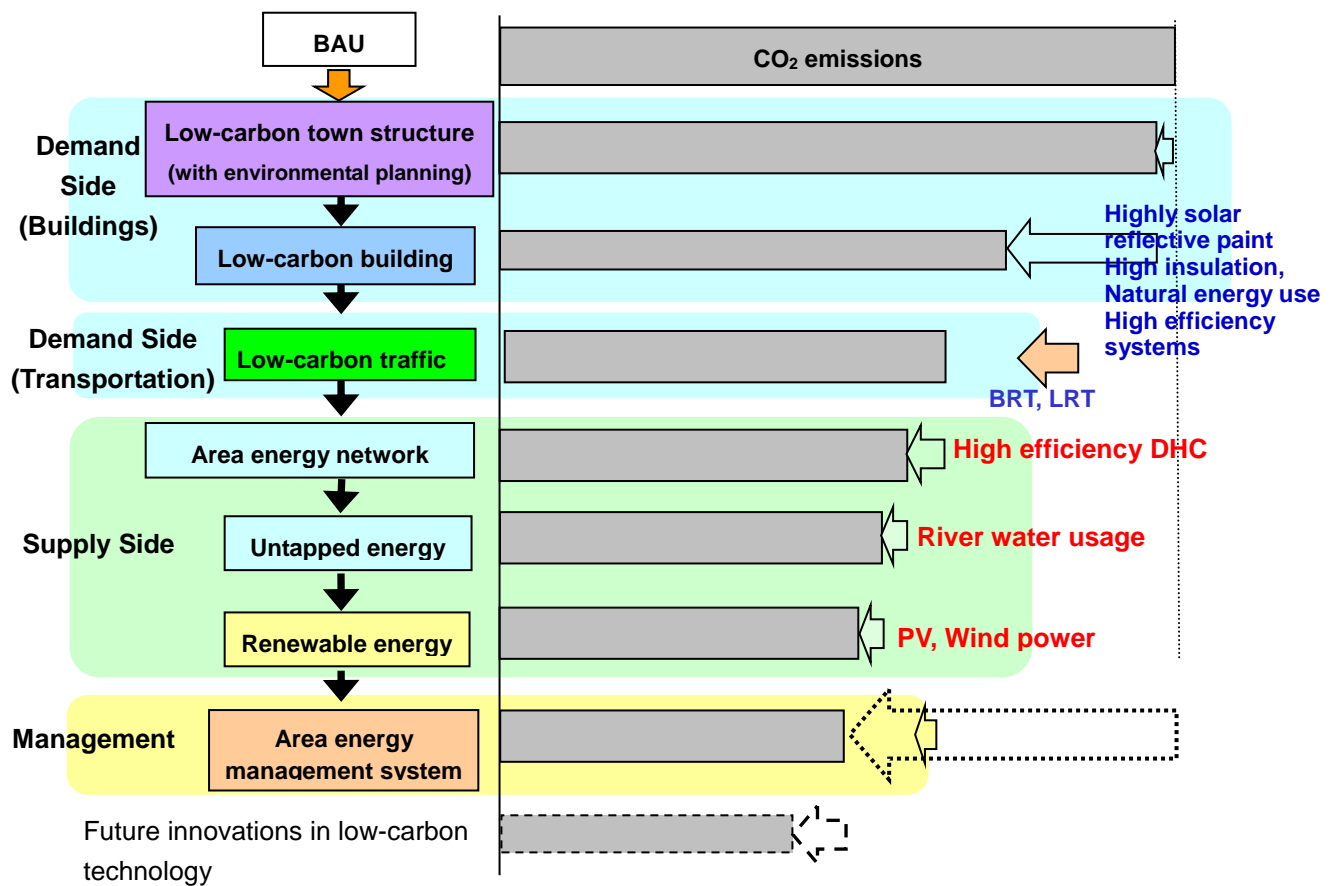
## Chapter 6 Evaluating the Effect of Low Carbon Measures

### 6.1 Purpose of Evaluating the CO<sub>2</sub>-Reducing Effects

Estimates of the reduction in CO<sub>2</sub> emissions from various measures and combinations of measures will make it possible to quantify the effectiveness of a planned approach to low-carbon town development. This also makes it possible to compare the predicted reductions with the designated CO<sub>2</sub> reduction target for the town, which provides a check on the practicality of the target itself and ongoing outcomes, which underpin updating of the strategy based on actual performance.

A hierarchy approach is recommended for the purposes of review. This uses the emissions level in a business-as-usual (BAU) scenario as the basis and assesses the increase in emission reduction in a hierarchical fashion as shown in Figure 23.

Figure 23 Hierarchical Approach for Assessing Effectiveness of Low-Carbon Measures



## 6.2 Basic Methodology to Evaluate CO<sub>2</sub>-Reducing Effects

Basic methodologies for evaluating the CO<sub>2</sub> reducing effects of the different measures are shown below.

### 6.2.1 Demand

#### i) Low-Carbon Town Structures (Transit Oriented Development (TOD) Type Land Use)

Low-carbon town structures are being discussed in terms of intensive town development and TOD-type development in CBDs, etc., and thus, it is difficult to envision application of intensive town structures for rural and resort areas. Consequently, the need to study such structures should be determined based on the existence of intensive development or TOD-type development.

TOD has two key CO<sub>2</sub> reducing effects:

- Reduced energy use in buildings through their concentration in high density zones
- Reduced motor traffic

The two methods used to evaluate the effects of TOD type land use are set out separately below.

#### ii) Low-Carbon Buildings

General Procedure for Evaluation

CO<sub>2</sub> emissions from the building sector can be calculated by multiplying 'total floor area of buildings by use', 'CO<sub>2</sub> emission intensity of buildings by use' and '(1- Overall CO<sub>2</sub> reduction rate)', as shown in the formula below.

$$\text{CO}_2 \text{ Emissions} = (\text{Total floor area of buildings by use}) \times (\text{CO}_2 \text{ emission intensity of buildings by use}) \times (1 - \text{Overall CO}_2 \text{ reduction rate})$$

Data

##### a) Total Floor Area of Buildings

The 'floor area of buildings by use' figure is estimated based on the development plan of the area in question.

##### b) CO<sub>2</sub> Emission Intensity of Buildings by Use

Method 1: If statistical data on the energy consumption of the buildings by use is available for the area in the development plan, a figure for CO<sub>2</sub> emission intensity data can be obtained by conversion of such data.

Method 2: If that data is not available, but data for other cities of a similar nature is accessible, this can be used to estimate a figure for the CO<sub>2</sub> emission intensity.

Method 3: If that data is not available from the development zone or similar cities, an alternative can be to gather data via a survey of energy consumption of buildings in the town in question. The

survey will have the greatest value if it documents seasonal differences in energy consumption and type of fuel use.

#### Estimation of the CO<sub>2</sub> Emission Reduction Effect of Each Measure

The overall CO<sub>2</sub> emission reduction rate can be calculated by following these steps:

1. Evaluate separately the CO<sub>2</sub> emission reduction effect at energy consumption points in the building, such as heat source equipment, heat transfer, lighting, electric apparatus, and hot-water supply system.
2. Estimate the aggregated value by prorating these figures.

Detailed data like this may not be available. However, energy utilities and oil companies should be able to provide overall usage data for their energy sources in the region. This provides a check of the bottom up estimation.

Heat-source equipment generates cooling or heating energy and includes turbo or absorption/adsorption-type refrigerators and heat-pump chillers, as shown in the schematic diagram of the district cooling/heating system in Volume II. The efficiency of this technology, especially of heat pumps, has been improved year after year. Replacing outmoded equipment with high efficiency models is an effective way of reducing CO<sub>2</sub> emissions. However, where end use efficiency measures are introduced, the capacity of plant may be reduced relative to BAU, reducing capital costs.

Heat distribution equipment includes cold/hot-water pumps and air conditioning fans. Effective energy savings can be achieved through adjusting the number of these equipment in operation and by using an inverter system to control their use according to actual demand. There have also been significant improvements in efficiency in this area in recent years, so replacement of the pumps and fans themselves may be justified.

In terms of lighting, energy savings can be achieved by adopting high-efficiency fluorescent lamps (Hf-type lamps), LED, organic EL lighting, illumination control using light sensors and motion sensors.

Reduction of the amount of electricity used for lighting and office appliances will result in reduced internal heat, which also contributes to a reduction in electricity consumption for cooling purposes.

The reduction in CO<sub>2</sub> emissions from the adoption of an area energy network, such as district cooling/heating (DHC) can be estimated in a similar way.

### **iii) Low-Carbon Transportation**

#### General Procedure for Evaluation

CO<sub>2</sub> emissions in the transportation sector can be calculated by the multiplication of 'traffic volume', 'distance travelled', and 'emission intensity' (equation shown as below). These figures need to be obtained in order to calculate the reduction effect of low-carbon transportation measures. As an example, a procedure for automobile traffic is set out below. For the other transportation modes

(ships, boats, aircrafts, etc.), the basic concept and the procedure of evaluation is the same, but more detailed data specified for the transportation mode is required. Again, top down data on transport fuel use should be used as a verification.

$$\text{CO}_2 \text{ emissions} = \text{Traffic volume} \times \text{Distance travelled} \times \text{Emission intensity}$$

#### a) Traffic Volume

If an automobile traffic census has been conducted in the targeted district, this should be used to determine traffic volume (including freight traffic). An automobile traffic census counts the number of vehicles passing a particular point of each district, by the type of vehicles, the time of the day and the direction. This is then used to calculate the traffic volume of each target district covered by the census, per day and per year, as well as providing insights into the kinds of vehicles and activities that are significant contributors to demand.

Person-trip surveys can also be used to calculate passenger traffic volume. A person-trip survey investigates 'when', 'what type of people' moved, 'from where', 'to where', 'by what means of transportation', and 'for what purpose' in a given district in one day. The survey, which studies the actual travel behaviour of the people living in the cities, is a valuable source of information for traffic planning.

A 'trip' is a unit for the movement of a person from one point to another for some purpose. The total of the number of trips that started from a certain district (traffic generation) and the number of trips that ended in the district (traffic concentration) is called the 'generation concentration volume' of the district.

While the modes of transportation covered by these surveys include railroads, buses, automobiles, two-wheeled vehicles (bicycles, motorised bicycles) and walking, it is possible to estimate the automobile traffic volume in a given district by calculating the generation concentration volume by the percentage use of automobiles. Person-trip survey data will provide automobile traffic volumes by types of vehicle and by routes.

#### b) Distance Travelled

If an origin/destination survey (OD survey) has already been conducted in the targeted district, this should be used to determine the travel distance of automobiles. An OD survey investigates the movement of the cars in one day, regarding information such as the point of departure and destination, purpose of the trip and time of travel. This is carried out by selecting a certain number of car owners from a car registry, who are then surveyed by questionnaires. The OD survey data will provide figures for distance travelled by the type of vehicle.

If a person-trip survey was used to calculate traffic volume, the distance travelled should be calculated as the distance of each route.

c) Emission Intensity

If statistical data on the fuel consumption and distance travelled by type of vehicle is available for the relevant driving conditions, the CO<sub>2</sub> emission intensity should be determined from these data. The CO<sub>2</sub> emission intensity should be settled separately by the type of vehicle and the type of fuel used by the vehicle. The contribution of air conditioners to vehicle fuel use should be estimated based on average travel times and climatic conditions.

Calculation of the CO<sub>2</sub> Emission Reduction Effect of Each Measure

a) Effects Attributable to the Upgrading of the Public Transit Network

In principle, the effects can be estimated by assuming the reduction of traffic volume and distance travelled, that will be achieved through upgrading of the public transit network, offset by the additional energy use of the PT network.

b) Effects Attributable to the Introduction of Low-carbon Vehicles

In principle, the effects can be estimated by assuming the number of low-carbon vehicles that will replace conventional vehicles and their emission intensity relative to business as usual.

c) Effects Attributable to the Introduction of Other Measures (such as Traffic Demand Management)

In principle, the effects can be estimated by assuming the change in traffic volume, distance travelled and emission intensity accordingly.

## 6.2.2 Supply

### i) Effects Attributable to the Introduction of an Area Energy System

The effects can be estimated by assuming the increase in efficiency at the central plants used for cooling, heating, hot-water supply and other purposes in the district.

### ii) Effects Attributable to the Introduction of Untapped Energy/Renewable Energy

Heat: The CO<sub>2</sub> emission reduction effect can be calculated by assuming the amount of fuel necessary to generate the same amount of heat produced by untapped energy/renewable energy

Electricity:

The CO<sub>2</sub> emission reduction effect can be calculated by reducing the electricity supply from the commercial grid, which is equivalent to the electricity generated by solar photovoltaic, etc.

### **6.2.3 Demand and Supply**

The CO<sub>2</sub> reduction effects can be estimated separately for different types of benefits, such as energy efficiency increase in building sectors or increase of renewable energy power generation.



# **The Concept of the Low-Carbon Town in the APEC Region**

## **Appendix and Index**

Sixth Edition

**Volume I**

**Main Chapter**

December 2016



## Appendix Low-Carbon Target for APEC Economies

Economy	Emission Reduction Target in 2015	Base year
Australia	Implement an economy-wide target to reduce greenhouse gas emissions by 26 to 28% below 2005 levels by 2030.	2005
Brunei Darussalam	Set an ambitious regional goal of a 45 percent energy intensity reduction by 2035 versus a 2005 baseline. This would heighten the importance of natural gas, given it is 'cleaner' than alternatives, such as crude oil and coal, which could generate up to 50 percent higher carbon dioxide emissions.	2005
Canada	Intends to achieve an economy-wide target to reduce greenhouse gas emissions by 30% below 2005 levels by 2030.	2005
Chile	<p>Chile has decided to present its contribution under the intensity of emissions framework (CO<sub>2</sub> tons equivalent per unit of GDP in million CL\$ 2011). In that sense Chile has defined two commitments:</p> <ol style="list-style-type: none"> <li>1. Carbon intensity goal, expressed in GHG per unit of GDP, without considering land use, land-use change or forestry-sector emissions: <ol style="list-style-type: none"> <li>a. Chile has the commitment to reduce its CO<sub>2</sub> emissions per unit of GDP by 30% by the end of 2030 compared to 2007 emissions.</li> <li>b. Additionally, and conditioned to the obtaining of international financial support, Chile could commit to reduce its CO<sub>2</sub> emissions between 35% and 45% compared to 2007 levels.</li> </ol> </li> <li>2. Specific contribution considering land use, land-use change and forestry-sector emissions: <ol style="list-style-type: none"> <li>a. Chile commits to recover 100,000 hectares of native forests, representing and expected capture and reduction in GHG in around 600,000 tons of CO<sub>2</sub> equivalent from 2030.</li> <li>b. Chile commits to forest 100,000 hectares mainly with native species, representing captures between 900,000 and 1,200,000 tons CO<sub>2</sub> equivalent per year from 2030.</li> </ol> </li> </ol>	2007
China	<p>China has nationally determined its actions by 2030 as follows:</p> <ul style="list-style-type: none"> <li>-To achieve the peaking of carbon dioxide emissions around 2030 and making best efforts to peak early;</li> <li>-To lower carbon dioxide emissions per unit of GDP by 60% to 65% from the 2005 level; and</li> <li>-To increase the forest stock volume by around 4.5 billion cubic meters on the 2005 level.</li> </ul>	2005
Hong Kong, China	<p>Proposed to set a carbon intensity reduction target of 50% - 60% by 2020 as compared with 2005 level.</p> <p>Set a target to achieve a reduction in energy intensity of at least 25% by 2030 (with 2005 as the base year)</p>	2005
Indonesia	<p>a) Unconditional Reduction</p> <p>Indonesia has committed to reduce unconditionally 26% of its greenhouse gases against the business as usual scenario by the year 2020.</p>	2010

	<p>The above commitment is a necessary prerequisite for embarking on a bolder commitment to further reductions by 2020 and beyond by outlining an emission reduction plan using an evidence-based and inclusive approach. The commitment will be implemented through effective land use and spatial planning, sustainable forest management which include social forestry program, restoring functions of degraded ecosystems, improved agriculture and fisheries productivity, energy conservation and the promotion of clean and renewable energy sources, and improved waste management.</p> <p>As stated earlier, Indonesia is committed to reducing emissions by 29% compared to the business as usual (BAU) scenario by 2030, as a fair reduction target scenario based on the [economy's] most recent assessment of the 2010's National Action Plan on GHG Reduction. The BAU scenario is projected approximately 2,881 GtCO<sub>2</sub>e in 2030.</p> <p>b) Conditional Reduction Indonesia's target should encourage support from international cooperation, which is expected to help Indonesia to increase its contribution up to 41% reduction in emissions relative to BAU by 2030.</p> <p>Indonesia's additional 12% of intended contribution by 2030 is subject to provision in the global agreement including through bilateral cooperation, covering technology development and transfer, capacity building, payment for performance mechanisms, technical cooperation, and access to financial resources.</p>	
Japan	A reduction of 26.0% by fiscal year (FY) 2030 compared to FY 2013 (25.4% reduction compared to FY 2005) (Approximately 1.042 billion t-CO <sub>2</sub> eq. as 2030 emissions)	2013
Korea	Plans to reduce its greenhouse gas emissions by 37% from the business-as-usual (BAU, 850.6 MtCO <sub>2</sub> e) level by 2030 across all economic sectors.	
Malaysia	Malaysia announced [economy] voluntary initiative to achieve up to 40 % reduction in emissions intensity of GDP by 2020 based on 2005 level with conditions that technology transfer and financial support provided from developed [economies].	2005
Mexico	<p>Mexico is committed to reduce unconditionally 25% of its greenhouse gases and short-lived climate pollutants emissions (below BAU) for the year 2030.</p> <p>The 25% reduction commitment expressed above could increase up to a 40% in a conditional manner, subject to a global agreement addressing important topics including international carbon price, carbon border adjustments, technical cooperation, access to low-cost financial resources and technology transfer, all at a scale commensurate to the challenge of global climate change.</p>	
New Zealand	Commits to reduce GHG emissions to 30% below 2005 levels by 2030	2005
Papua New Guinea	PNG's current economic development is seeing a growth in fuel use. Therefore, a big effort will be to reduce fossil fuel emissions in the electricity generation sector by transitioning as far as possible to using renewable energy. The target in this respect will be 100% renewable energy by 2030, contingent on funding being made available. In addition, PNG will improve energy efficiency sector wide and reduce emissions where	

	possible in the transport and forestry sectors. The main forestry effort will be coordinated through the existing REDD+ initiative.	
Peru	<p>The Peruvian Intended Nationally Determined Contribution (INDC) envisages a reduction of emissions equivalent to 30% in relation to the greenhouse gas (GHG) emissions of the projected business-as-usual scenario (BaU) in 2030.</p> <p>Peru considers that a 20% reduction will be implemented through domestic investment and expenses, and public and private resources (non-conditional proposal), and the remaining 10% is subject to the availability of international financing and the existence of favourable conditions (conditional proposal).</p>	
The Philippines	The Philippines intends to undertake GHG (CO <sub>2</sub> e) emission reduction of about 70% by 2030 relative to its BAU scenario of 2000-2030. Reduction of CO <sub>2</sub> e emissions will come from energy, transport, waste, forestry and industry sectors. The mitigation contribution is conditioned on the extent of financial resources, including technology development & transfer, and capacity building, that will be made available to the Philippines.	
Russia	Limiting anthropogenic greenhouse gases in Russia to 70-75% of 1990 levels by the year 2030 might be a long-term indicator, subject to the maximum possible account of absorbing capacity of forests.	1990
Singapore	In accordance with Decision 1/CP.19 and 1/CP.20, Singapore communicates that it intends to reduce its Emissions Intensity by 36% from 2005 levels by 2030 and stabilise its emissions with the aim of peaking around 2030.	2005
Chinese Taipei	<p>(1) The Aim of Energy Conservation</p> <p>Chinese Taipei aims to annually increase more than 2% of energy efficiency next eight years, make energy intensity decrease by 20% or above in 2015 comparing with 2005, and make energy intensity decrease by 50% or above in 2025 by means of technological breakthroughs and supporting measures.</p> <p>(2) The Aim of Carbon Reduction</p> <p>It intends to reduce national carbon dioxide emissions, that is, the amount of emissions in 2020, to the amount in 2005, and decrease the amount of carbon dioxide emissions in 2025 to the amount in 2000.</p>	2005
Thailand	<p>Thailand intends to reduce its greenhouse gas emissions by 20% from the projected business-as-usual (BAU) level by 2030.</p> <p>The level of contribution could increase up to 25%, subject to adequate and enhanced access to technology development and transfer, financial resources and capacity building support through a balanced and ambitious global agreement under the United Nations Framework Convention on Climate Change (UNFCCC).</p>	2005
United States	The United States intends to achieve an economy-wide target of reducing its greenhouse gas emissions by 26-28% below its 2005 level in 2025 and to make best efforts to reduce its emissions by 28%.	2005
Viet Nam	Viet Nam's INDC identifies the GHG reduction pathway in the 2021-2030 period. With domestic resources, GHG emissions will be reduced by 8% by 2030 compared to the business-as-usual scenario (BAU). The above-mentioned contribution could be increased up to 25% with international support.	2006

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