Low Carbon City Development Guidance

[Outline]

Ministry of Land, Infrastructure, Transport and Tourism JAPAN

Chapter 1　What is the Low-carbon City Development Guidance?

Chapter 1 explains the purpose of the Guidance, its contents, and the situations which may call for it.

(1) Purpose of the Guidance

Purpose of the Guidance

To describe the basic concepts of a low-carbon city, particularly:

1) **The basis of the development of a low-carbon city, and**
2) **The methodology to assess the effects of measures to develop a low-carbon city with required numerical data.**

Greenhouse gases (GHGs), a principal cause of global warming, are emitted in large quantities in cities where various activities are carried out intensively and where significant volumes of energy are consumed. The Kyoto Protocol Target Achievement Plan requires urban governance to promote low-carbon societies.

On the other hand, urban activities are diverse and complex, requiring a wide range of measures to cope with global warming. There is also a need to analyze current GHG emissions and absorptions at the urban level to predict the effects these countermeasures will have on greenhouse gases.

To this end, the Guidance has been formulated to support the initiatives of local authorities, by indicating what should be considered when promoting low-carbon city development, its basic concepts, as well as the necessary measures and methods of assessing their effects.

The contents of the Guidance will regularly be updated to keep up with the changing needs and stay abreast of emerging issues.

(2) Contents of the Guidance

The Guidance consists of three parts: “Part I: Concept of a Low-carbon City” sets out the rationale for creating low-carbon cities. “Part II:　Low-carbon City Development Measures” describes the methods in developing a low-carbon city in three sectors, namely transportation and urban structure, energy (private homes and private businesses), and greenery. “Part III: Analysis of the Effects of　Low-carbon City Development Measures” explains the methodologies for assessing the effects of the measures.

(3) Scope of the Guidance

1) Target greenhouse gas

The type of greenhouse gas covered by the Guidance is carbon dioxide (CO_2), which is the most significant greenhouse gas in Japan and is closely related to urban structure.

2) Types of measures

The descriptions in the Guidance cover a broad range of measures, both “tangible” and “intangible”, to reduce CO_2 emissions which can be adopted in various fields related to urban development.

In addition, the Intergovernmental Panel on Climate Change divides the measures into two types, namely “mitigation measures” and “adaptation measures.” The aim of mitigation measures is to slow the trend of global warming by reducing GHG emissions. Adaptation measures aim to alleviate the adverse impacts of global warming (e.g., rising temperatures) by adjusting social and economic aspects. These two measures relate to urban development measures in different ways. Mitigation measures include conversion to a compact urban structure, promotion of public transportation use, efficient use of energy, and CO_2 sink such as the promotion of urban greenery. Adaptation measures, meanwhile, include the response to localized torrential rains and temperature increases, efficient use of water to cope with the depletion of water resources, among others. Both

mitigation and adaptation measures are important to cope with global warming and should be implemented in a balanced way.

In the Guidance, mitigation measures focus on radical steps to cope with global warming, while adaptation measures are examined in response to future scenarios.

(4) Expected Use for the Guidance

The Guidance is categorized as a technical advice based on the provisions of Article 245–4 of the Local Autonomy Law. Its application is left to the discretion of local authorities, but it is expected to be used in the following:

- The development of a low-carbon city when revising city planning master plans, etc.;
- Consideration of low-carbon policies in developing Comprehensive Urban Transportation Strategy, urban transportation facilities, redevelopment projects, and urban facilities development;
- Analysis of the effects of measures to develop a low-carbon city.

The above-mentioned situations and methods to use the Guidance will be elaborated in future revisions.

The Guidance is expected to be used by government departments in charge of environmental measures and other concerned departments, while it will mainly be used by city authorities in charge of urban development to enable them to comprehensively manage the development of a low-carbon city.

The Guidance took into consideration the following points as regards its analytical methods:

- Methods should enable local authorities to accumulate data needed for analysis (e.g., for use in basic surveys in city planning), and
- Multiple patterns of practicable evaluation in view of data limitations and the burden of administrative work on local authorities.

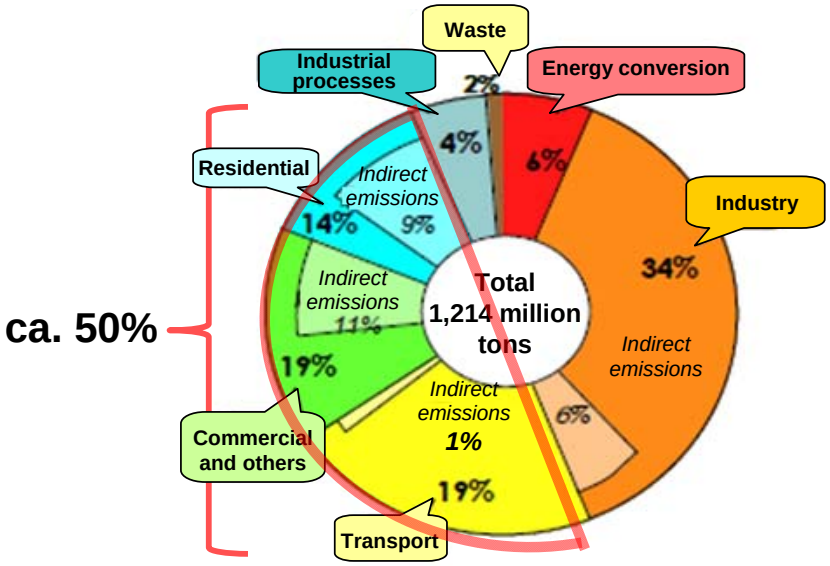
Chapter 2 Background on the development of a low-carbon city

Chapter 2 explains the relationship between global warming and cities, including what urban activities contribute to global warming and why city-based initiatives for reducing carbon levels must be pursued.

(1) Global warming and the present status of urban activities

1) More than half of all CO_2 emissions result from socio-economic activities in cities

Global warming, a serious environmental problem that could affect the survival of the human race, is caused by greenhouse gases emitted from human activities. In the case of Japan, about 50% total CO_2 emissions are attributed to socio-economic activities in the cities—residential sector, business sector (e.g., offices and shops), and transportation sector (roads, railways, etc.).



Source: Greenhouse gas emissions in FY2008 (definite value):(Ministry of the Environment)

Fig. 1 Breakdown of CO_2 Emissions (FY2008)

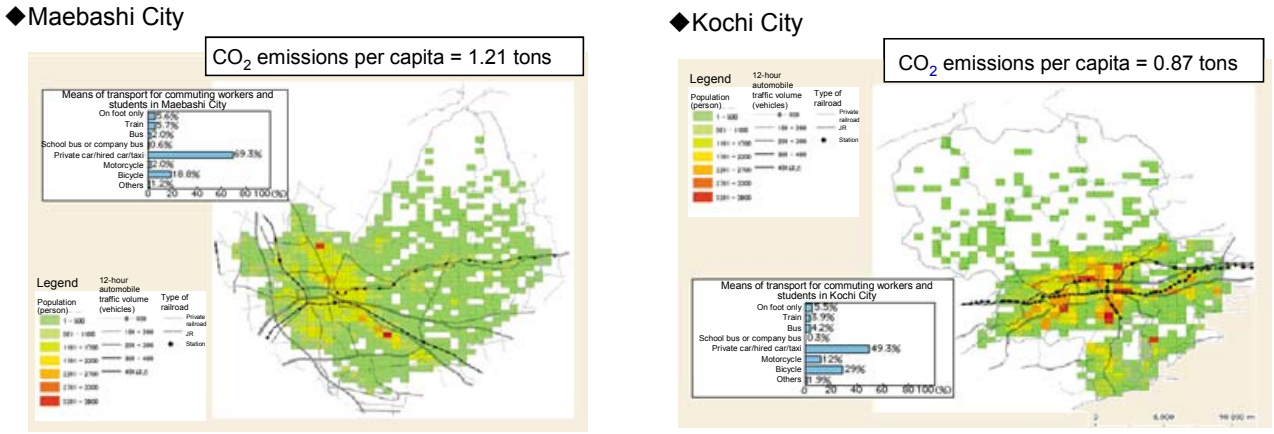
(2) Interrelationship among urban activities, urban structure, and global warming

1) Urban activities and CO_2 emissions

- In the transportation sector: Motorization and growing dependence on passenger cars in daily life;
- In the business sector: Expansion of offices and shops, increased energy consumption due to 24-hour operation, etc.;
- In the residential sector: Expansion of floor areas due to increasing numbers of households as a result of the growth of nuclear families and single households, progress of IT, and increasing sizes of home appliances, etc.;
- Accumulation of buildings and structures which are not energy-efficient or low-carbon emitting, since energy efficiency has lower priority compared to convenience, comfort, and economy;
- Heat island phenomenon due to the proliferation of buildings and pavement at the expense of greenery and water bodies, and the negative changes in the thermal environment due to increased energy consumption for heating and cooling; and
- Reduced CO_2 sink due to loss of greenery in cities along with urbanization.

2) Urban structure and CO_2 emissions

Although the cities of Maebashi and Kochi are almost the same in terms of area and population, Maebashi has a greater expanse of low-density built-up areas and a higher rate of dependence on automobiles. As a result, per capita annual CO_2 emissions in the transportation sector in Maebashi is about 40% higher than that in Kochi.

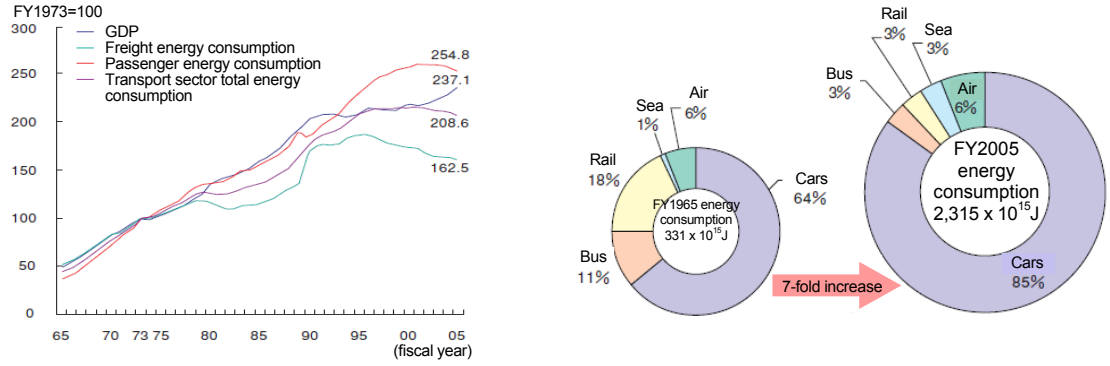


*1 CO_2 emissions per capita above is restricted to passenger transportation sector

Source: Environmental White Paper in FY2006

Fig. 2 CO_2 emissions per capita in the transportation sector in Maebashi and Kochi

The diffusion and proliferation of urban functions have caused problems at both the levels of global environment and living environment. It is feared that they will lead to the increased use of private cars and longer traveling distances, etc., a resultant increase in CO_2 emissions, and a greater load being placed on the environment. Another problem is that road congestion in built-up areas will be further aggravated, placing an even heavier burden on living environments. Until now, as a quick response to the rapid concentration of population in cities, housing land has mainly been provided in suburban areas, leaving city centers with relatively low levels of land use. This outward expansion of cities has given rise to an urban structure producing a large environmental burden, particularly in terms of traffic problems. As a reaction to this, the need to make cities more compact and follow an urban structure that places a lighter burden on the environment has been pointed out in recent years.



Source: Cabinet Office, "National Economy Statistics Yearbook"; Agency for Natural Resources & Energy, "Comprehensive Energy Statistics"

Source: Agency for Natural Resources & Energy, "Comprehensive Energy Statistics"

Fig. 3 Trends in energy consumption in the transportation sector

Meanwhile, the occurrence of heat islands and urban temperatures are forecast to rise due to the loss of green space, higher energy consumption, increased density in built-up areas, and deteriorated air and water circulation, among other factors. At the same time, the protracted use of cooling systems due to reduced air circulation in buildings, heat emissions from computers, etc., and use of coolers are instead of heaters. All this is expected to raise energy consumption.

In view of this close relationship between global warming and cities, the radical solution of re-forming the urban structure will have to be done to reduce global warming.

Chapter 3 Basic concept of the development of a low-carbon city

Chapter 3 presents the rationale and goals in creating low-carbon cities.
In addition to converting cities to a more compact structure, it is important that carbon emissions be reduced simultaneously in each sector.
This chapter presents the rationale on converting to an intensive urban structure, as well as efforts in the three sectors of transportation and urban structure, energy, and greenery, on creating low-carbon cities.

(1) How urban activities and structure are related to CO_2 emission

To mitigate global warming, it is vital to reduce emissions and increase the absorption of CO_2. In Japan, CO_2 emissions mostly arise from energy use. The introduction of untapped and renewable energy sources will be fundamental to reducing emissions, together with the promotion of energy conservation in transportation, residences, and industries.

Meanwhile, CO_2 sink measures depend on increasing removals by sinks of greenery in built-up areas as well as farmlands and woodlands surrounding built-up areas. This kind of "urban greening" will also help to reduce the heat island phenomenon.

As stated in Chapter 2, changes in urban structure may have an impact on CO_2 emissions. It will also be important to strive to reduce CO_2 emissions in each sector along with a shift to a compact urban structure, such as by rearranging the spatial forms of cities, urban functions, green areas or open spaces, etc.

(2) Conversion to a compact urban structure

A compact urban structure has centers ("integrated centers") in its central built-up area and around main transportation hubs, among others, to promote the accumulation of urban functions. These integrated centers are organically linked with other areas in the metropolis via public transportation networks, thereby ensuring a better quality of life for citizens and the sustainable development of the metropolis.

(3) Efforts at developing low-carbon city models in line with the shift to a compact urban structure

In order to develop a low-carbon city, it is important to incorporate measures for reducing emissions and increasing absorptions of CO_2 in conjunction with a shift to a compact urban structure. Based on the above-mentioned impact of urban structures on CO_2 emissions, a low-carbon urban development model is organized into the following three areas:

(Initiatives in transportation and urban structure sector)

In terms of energy consumption in the sector, a compact urban area where people can live closer to their workplaces is expected to reduce travel distances and alleviate transportation demand. Reduced travel distances, in turn, will promote a shift from passenger cars to bicycles or walking. Moreover, increasing the density of traffic demand can raise the profitability levels of public transportation, thereby improving its service levels, which can further promote a shift from automobiles to public transportation.

(Initiatives in the energy sector)

The shift to a compact urban structure should be tackled uniformly across sectors to allow cities to shift to low-carbon, high-efficient energy systems.

A highly dense and complex land use in integrated centers can enhance energy efficiency and can introduce highly efficient, area-wide energy systems with improved energy demand densities and levels. In addition, it can introduce energy systems that utilize low-carbon energy sources by developing urban functions close to untapped energy sources (factories, waste incineration plants, sewage treatment plants, etc.).

(Initiatives in the greenery sector)

It is important to pay attention to “greenery” as a key element in defining urban structures in order to switch to a low-carbon city. Greenery is not only a source of CO_2 sink, but also mitigation of urban climates that can indirectly reduce CO_2 emissions caused by coolers and heaters. Greenery sector is also closely related to biomass energy. When urban structures are rearranged, it is possible to promote a conversion to low-carbon city by attempting quantitative and qualitative enhancement of greenery in suburban areas and city centers.

As outlined above, it is important to attempt a conversion to low carbon in conjunction with a shift to a compact urban structure. However, since diverse activities unfold in complex ways in cities, initiatives aimed at a conversion to low carbon can be highly diverse in nature, irrespective of the integration of urban structures. For example, they may include measures leading directly to reduced carbon emissions (e.g., introduction of untapped or renewable energies) or measures that contribute to the conversion to low carbon while achieving other objectives (e.g., transportation measures, protection of woodlands and farmlands, etc.).

Urban policies, in particular, often have multiple objectives. When considering a low-carbon city in urban development, it is important to comprehensively implement measures that lead to a low-carbon city while achieving the objectives of these diverse urban policies, such as convenience, disaster prevention, maintaining vitality, etc. (for example, attempting to balance efforts to reduce CO_2 with an increase in floor areas and increased transportation activity, etc., accompanying the growth of cities).

Compact cities with an intensively developed urban functions can respond to population decline and aging society, while maximizing the efficiency of urban management costs. They efficiently materialize good living environments and interaction spaces, where people can choose to live a certain lifestyle depending on the local conditions and where necessary urban functions and public services are concentrated. This kind of compact urban structure will also be a low-carbon urban structure, thus reducing the maintenance costs of cities and improving urban landscapes, among others. Therefore, low-carbon city development itself makes a huge contribution to achieving the objectives of other urban policies.

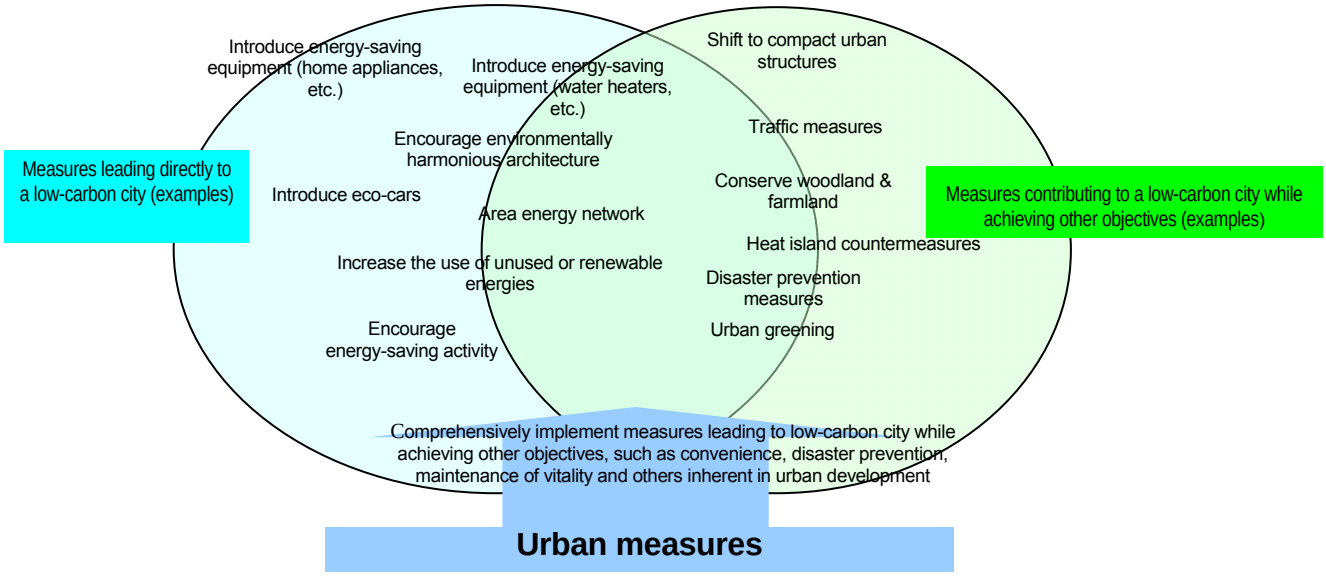


Fig. 4 Correlation between urban and low-carbon measures

Low-carbon city development concept and policy

Since reforms of the urban structure are closely related to reduction of CO_2 emissions, it is important not only to convert cities to more compact structures, but also to strive for reduced carbon emissions in the sectors of energy and greenery.

Concept of the development of a low-carbon city

- Selection of effective CO_2 reduction measures based on the status and structure of CO_2 emission in a city is necessary.
- Understanding the current level of CO_2 emissions in comparison to other cities is necessary to examine oneself and decide what measures are effective in which areas.
- As for the selection of measures based on self-assessment above, clarified 9 policies for each area of "transport/urban structure", "energy" and "greenery", in line with transformation based on compact urban structure→Volume Ⅱ summarizes measures based on the 9 policies.
- Specific procedure to understand the effect based on the selection and combination of the measures are shown in Volume III.

Shift to a compact urban structure

- Realize compact urban structure that is compact based on mixed-use of facilities for efficient land use and preservation of natural environment ⇒ policy 1
- Realize traffic system not excessively dependent on automobile ⇒ policy 2, 3

Efforts to develop a low-carbon city when making shift to a compact urban structure

- Shift to an urban structure sets right conditions and provide opportunities to implement measures in energy and green areas .
- Move away from city activities dependent on heavy energy consumption and establish energy supply system that circulates in an area ⇒policy 4,5,6
- Secure green spaces in every corner of a city and around a city⇒policy 7,8,9

A. Realize compact urban structure and transportation measures (shift from diffused urban structure to compact urban structure)

Policy 1 Realize compact urban structure

- Location of public facility/service facility etc. and houses in a hub
- Leveling of energy demand based on compound (mixed) land use
- Encourage relocation of large scaled heat demand facilities to areas close to unused energy sources
- Build a green network by promoting greening of cities and preserving green areas around cities

Policy 2 Promote measures to address traffic flow

- Road improvement for smooth automobile traffic
- Traffic demand management

Policy 3 Promote the use of public transport

- Development of public transport of services

B. Efficient use of energy and use of unused/renewable energies (Move away from city activities dependent on heavy energy consumption)

Policy 4 Renovation to energy saving buildings that contribute to low-carbon society

- Realize efficient energy use by seizing opportunities of building renewal as part of efforts to realize compact structure .
- Encourage to locate energy saving buildings that matches with the surrounding environment

Policy 5 Area Energy Network

- Introduction of Area Energy Network by seizing opportunities of holistic urban function renewal etc.

Policy 6 Utilization of unused/renewable energy

- Adjustment of stock and demand of unused energy
- Utilization of renewable energy
- Promotion of district-scale introduction of unused/ renewable energy in times of urban development

C. Conservation of green spaces and promotion of urban greening (coexistence with nature)

Policy 7 Securing of carbon sink

- Conserve and create green areas
- Conserve urban greening in collaboration with the citizens, etc.

Policy 8 Promotion of the use of wood-based biomass

- Protect and manage green spaces, use wood biomass in built-up areas

Policy 9 Improvement of thermal env't thru heat island countermeasures

- Link heat island countermeasures in accordance with diversity of scale

Specify land use | *Concentrate urban functions* | *Secure biodiversity with greenery* | *Make efficient/ environmentally friendly buildings* | *Improve traffic efficiency/ operation frequency*

Realize a low-carbon and compact urban structure

Policy menu of low-carbon city development

In this section, menus and examples of measures for the transportation and urban structure sector, the energy sector, and the greenery sector are provided.

Land use | Urban functions | Greenery | Building | Traffic/ Travel

Transportation/urban structure

Menu 1 Shift to a compact urban structure
(1) Location of public facility/service facility etc. and houses in a hub

Menu 2 Road development (improve traveling speed)
(1) Road improvement for smooth automobile traffic (2) Grade separated intersection (3) Measures against bottleneck railroad crossing . (4) Promotion of ITS (Intelligent Transport System)

Menu 3 Adjust the demand for automobile traffic (traffic demand management)
(1) P&R, P&BR (2) Transit mall (3) Car sharing (4) Car pooling (5) Improve environment for bicycle riding (6) Telework (7) Mobility management (8) Parking management (fringe parking, parking supply control, parking fee control)

Menu 4 Development of public transportation
(1) Development of railroad, LRT, BRT (2) IIntroduction of community bus (3) Enhancement of bus lane (4) Enhancement of traffic junction like open space in front of stations

Menu 5 Promote the use of public transportation
(1) Figure out a better way of setting fare (2) Improve service frequency (3) IImprove the service at bus stops (4) Utilization of IT (IC card introduction etc)

Energy

Menu 6 Measures to reduce energy load
(1) Large-scaled renovation of antiquated buildings (2) Area Energy Management Systems (AEMS)

Menu 7 Measures to improve energy efficiency
(1) Area energy network (a. district heating and cooling, b. Interchange of heat among buildings) (2) Complex use of land (mixed use)

Menu 8 Measures to utilize unused energy
(1) Waste heat of garbage processing plant (2) Unused energy of sewerage facilities (3) Energy generated by temperature difference of rivers and oceans (4) Energy generated by temperature difference of underground water (5) Waste heat of factories (6) Waste heat of subway/underground shopping mall (7) Cold energy power generation from ice and snow

Menu 9 Measures to utilize renewable energy
(1) Use of solar energy (a. Power generation b. Heat generation) (2) Utilization of soil heat (3) Utilization of biomass energy

Greenery

Menu 10 Measures based on city master plan/city planning/ordinance, etc.
(1) Greenery measures linked to public transportation and land use (2) Green belts (3) Effective use of arable land (4) Greening of vacant space

Menu 11 Measures to develop parks and green spaces, and promote greenery
(1) Tree planting projects (2) Social & Environmental Green Evaluation System (SEGES)

Menu 12 Measures to manage and grow greenery
(1) Green-shaded road projects (2) Citizens' forests

Menu 13 Impose green tax/donation system
(1) Prefectural green tax (2) Green tax ordinance (3) Greening subsidy (4) Corporate sponsors

Menu 14 Conserve and properly manage large green areas
(1) Nature restoration projects (2) Wood-based resources recycling system

Menu 15 Utilize wood-based biomass
＜As a source of renewable energy＞
(1) Forest management and timber utilization project (2) Promotion of forest measures and use of wood biomass (3) Wood biomass gasification power generation project
＜Use as compost or woodchips＞
(1) Greening of expressways (2) Green tax ordinance (3) Greening subsidy (4) Corporate sponsors

Menu 16 Implement Heat island countermeasures
＜Wide-area scale＞
(1) Macro-simulation (2) Grand design of urban environment infrastructure (3) Special green space conservation districts
＜Urban scale＞
(1) Urban environment climate maps (2) Greening area system (3) Water and greenery networks (4) Water and greenery networks taking account of wind paths, etc.
＜District scale＞
(1) Development taking account of wind paths, etc. (2) Green curtains (3) Converting schoolyards to grass (4) Greening ratios (5) Formation of green shade

intensify | *complex* | *Nature friendly* | *Efficient Environment friendly* | *Improve Efficiency/ Operation frequency*

Realize a low-carbon, compact urban structure

Estimates of CO_2 Reduction and Absorption

Method of calculating CO_2 emissions in the transportation and urban structure sector

Cars are the main sources of CO_2 in the transportation sector, accounting for about 90% of emissions in the sector. Therefore, measures to reduce such CO_2 emissions are key low-carbon measures in the transportation and urban structure sector.

Formula for calculating CO_2 emissions in the transportation sector

CO_2 emissions = traffic volume × travel distance (trip length) × emissions intensity

Selection of methods for impact analysis in the transportation and urban structure sector

3 methods of predicting effects in the sector

Method 1 Calculation based on person-trip survey data
* A 4-stage estimation method is used to calculate the effects of a set of measures in line with a pre-set traffic scenario

Method 2 Calculation based on census OD survey data
* Calculation based on sample calculations of the range of impact of, and reduction obtained through, each measure based on the conditions in each city

Method 3 Calculation of the effect of individual measures
* Evaluation method will be developed with prerequisite conditions, in case there is no applicable analysis method

Method of calculating CO_2 emissions in the energy sector

The building floor area will be used as an activity volume to quantify CO_2 emissions, since low-carbon strategies in the energy sector mainly focus on reducing CO_2 emissions of buildings.

Formula for calculating CO_2 emissions in the energy sector

CO_2 emissions = gross floor area × unit energy load of a building ÷ the overall energy efficiency of heat reservoir × emission factor by type of energy

4 directions in energy

Assuming that building floor area is the same, 4 directions toward low-carbon cities in the energy sector with a view to reducing CO_2 emissions in other elements are set as follows:

1) **Reduce energy load of buildings**
   → Construct buildings requiring low energy to power coolers, heaters, etc., and reduce the unit energy load
2) **Improve efficiency of buildings, districts, and towns**
   → Introduce equipment with high energy efficiency and improve the total energy efficiency of heat resevoir
3) **Utilize unused energy**
   → Replace fossil fuels with unused energy and reduce the coefficient of energy emissions per type of energy
4) **Utilize renewable energy**
   → Replace fossil fuels with renewable energy and reduce the coefficient of energy emissions per type of energy

Method of calculating CO_2 fixation and sink in the greenery sector

Increasing greenery is the only measure to increase CO_2 sink in cities. Meanwhile, the effect of conserving and creating urban greenery can be directly quantified as "CO_2 fixation and sink" effect, since fixation and sink data have already been more or less developed for tall trees.

Formula for calculating CO_2 fixation/sink in the greenery sector

Effect of CO_2 fixation/sink = activity volume 1 × sink coefficient 1+ … +activity volume n × sink coefficient n

Examples of Calculations Based on Simulation

The following is a result of a simulation based on the Guidance, assuming that ambitious measures are implemented in the Sendai metropolitan area.

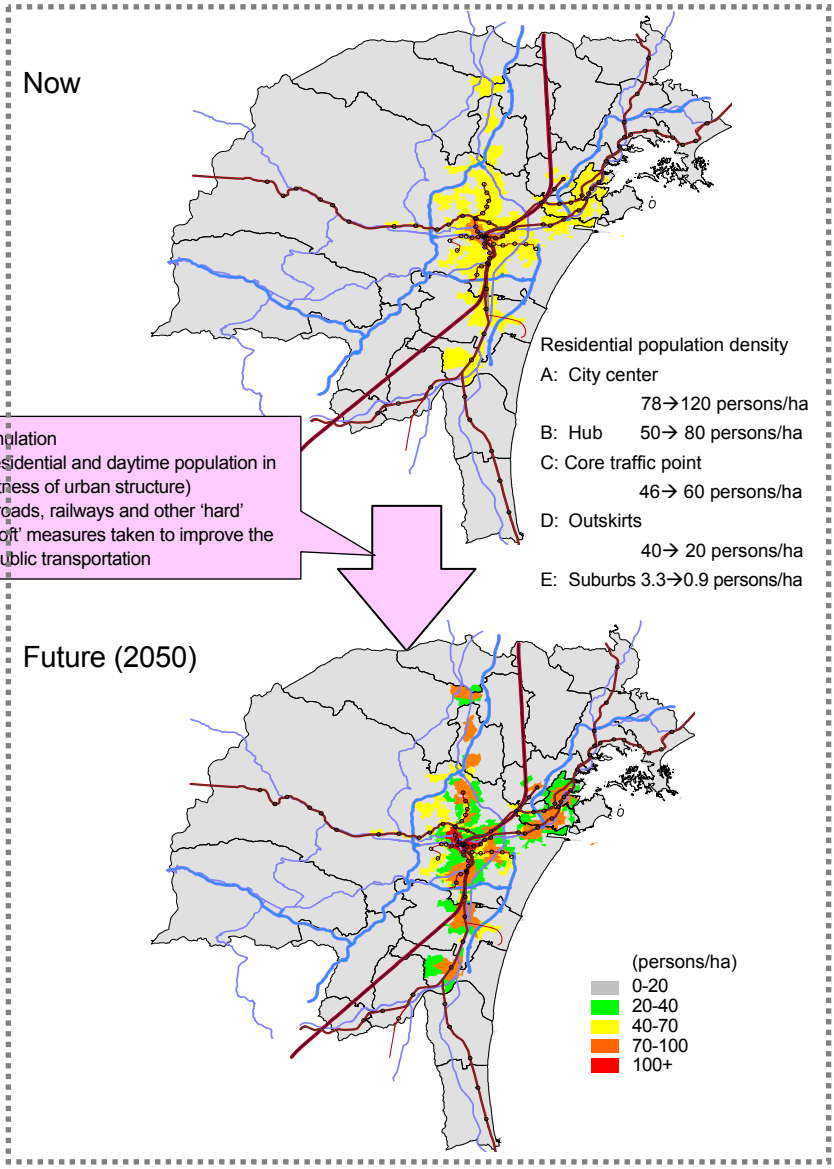
Set preconditions concerning urban development measures

(with 30 or more indicators which can be set in even greater detail)

- Residential population distribution and density (intensity level)
- Status of transportation infrastructure and implementation of 'intangible' measures
- Redevelopment of buildings, etc.
- Renewal of buildings etc.

Preconditions for simulation
- Aggregation of residential and daytime population in centers (compactness of urban structure)
- Development of roads, railways and other 'hard' amenities, and 'soft' measures taken to improve the convenience of public transportation

Simulation by systematically organizing various elements



* Various combinations of measures can be compared by changing the preconditions

Calculate change in CO_2 emissions of the whole city in response to a combination of measures

CO_2 emissions from traffic in a compact city by 2050 would be:
Reduced by 24.0% compared to the current level **(820,000t CO_2 /year)**

Effect of conversion to a compact urban structure (concentration of population in centers) in terms of increased efficiency of movement, etc. : 12.0% reduction

Effect of traffic measures : 4.9% reduction

Effect of population reduction : 7.1% reduction

< Obtaining method >
The Low Carbon City Development Guidance can be obtained on the following and the Ministry of Land, Infrastructure, Transport and Tourism homepages.

http://www.mlit.go.jp/crd/city_plan/teitanso.html

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< Issue >
January, 2011 .