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A Low Carbon Development Guide for Local Government Actions in China

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Abstract

Local level actions are crucial for achieving energy-saving and greenhouse gas emission reduction targets. Yet it is challenging to implement new policies and actions due to a lack of information, funding, and capacity. This is particularly the case in developing countries such as China. Even though national energy intensity and carbon intensity targets have been set, most local governments do not have the knowledge regarding actions to achieve the targets, the cost-effectiveness of policies, the possible impact of policies, or how to design and implement a climate action plan.

This paper describes a guidebook that was developed to motivate and provide local governments in China with information to create an action plan to tackle climate change and increase energy efficiency. It provides a simple step-by-step description of how action plans can be established and essential elements to be included—from preparing a GHG emission inventory to implementation of the plan. The guidebook also provides a comprehensive list of successful policies and best practices found internationally and in China to encourage low carbon development in industry, buildings, transportation, electric power generation, agriculture and forestry.

This paper also presents indicators that can be used to define low-carbon development, as well as to evaluate the effectiveness of actions taken at an aggregated (city) level, and at a sectoral or end use level. The guidebook can also be used for low carbon development by local governments in other developing countries.

Introduction

Local level actions and leadership are crucial for achieving national energy-saving and greenhouse gas emission (GHG) reduction targets. Local level actions can also assist in proving the effectiveness of new policies or initiatives by demonstrating them at a smaller scale. It is often also shown that innovative policies or practices can be relatively easily implemented at the local level because of the reduced scale and the possibility of exemption from national legislative bureaucracy. Following success at the local level, the pilot policies or practices can be replicated in other localities or expanded to a national program. For example, China's Top-1000 Enterprise Program drew upon the successful experience from a demonstration program implemented in two steel mills in Shandong province that was modeled after the voluntary agreement programs in The Netherlands and the UK (Price et al., 2003).

In developed countries, state and local level initiatives have proven to be very successful in transforming markets by engaging businesses and educating citizens. In the US, many states, cities and counties have forged ahead with dedicated funding and strategic policies to promote energy efficiency and renewable energy. California -- one of the best examples -- has set ambitious energy efficiency and GHG emission reduction targets and has implemented stringent, innovative policies and actions to improve energy efficiency and reduce emissions. As a result, California's per capita electricity consumption is 40% less than the average per capita electricity use in the U.S. California's experiences have often been replicated or echoed in other states, and some of the policies eventually became national regulations. Many federal appliance standards today are the direct result of such state leadership (REEEP, 2010). In addition, the experience also demonstrates that the adoption of a comprehensive energy and climate plan can stimulate the local economy, create green jobs, as well as produce new revenue (Roland-Holst, 2008).

Even so, it is challenging to initiate and implement new policies and actions due to a lack of information, funding, and capacity. This is particularly the case in China. Even though national energy intensity and carbon intensity targets have been set, most local governments do not have the knowledge regarding what they can do to achieve these goals, the cost-effectiveness of policies, the possible impact of policies, or how to design and implement a climate action plan.

Regarding low carbon development in China, the Chinese government announced a policy (Notice of Piloting Low-Carbon Provinces and Low-Carbon Cities) for establishment of Low-Carbon Cities and selected five provinces and eight cities as pilots in August 2010. The five provinces are Guangdong, Liaoning, Hubei, Shaanxi and Yunnan; and the eight cities are Chongqing, Shenzhen, Xiamen, Hangzhou, Nanchang, Guiyang, and Baoding. The policy outlines the following activities[1]:

1. Develop Low-Carbon Development Plan
2. Establish supporting policies to support low-carbon development
3. Establish low-emission industries
4. Establish GHG data collection and management systems
5. Promote low-carbon/green lifestyle and consumption model.
6.

As more attention is being paid to low-carbon cities and in response to the goal of reducing carbon intensity by 40-45% by 2020 from the 2005 level, many other cities or counties are also following the trend toward low carbon development. However, many of these so-called "low carbon cities are actually "high carbon" as no consistent definition, or scientific scope or indicators have been developed. Some supposedly low-carbon cities built wide roads; although lined with beautiful trees, the roads encouraged *more* vehicle use. Some cities excluded imported electricity from their carbon accounting. Thus, it is important to clearly define indicators, standardize the development process, and indentify policies, programs, technologies and measures that can be undertaken to realize carbon emission reductions (or carbon intensity reductions) in participating cities.

This paper describes a guidebook that was developed to motivate and provide local governments in China with information to create an action plan to tackle climate change and increase energy efficiency. It provides a simple step-by-step description of how action plans can be established and essential elements to be included—from preparing a GHG emission inventory to implementation of the plan. The guidebook also provides a comprehensive list of successful policies and best practices internationally and in China to encourage low carbon development in industry, buildings, transportation, electric power

[1] The proposed activities are guidelines for cities to develop the plans and it is unclear what measures will be adopted. In general, policies such as incentives, standards and labeling scheme, quotas have all been proven effective both internationally and in China.

generation, agriculture and forestry. Where available, the GHG emission reduction potential and cost-effectiveness of policies are also provided.

This paper also presents indicators that can be used to define low-carbon development, as well as to evaluate the effectiveness of actions taken at an aggregated (city) level, and at a sectoral or end use level. The paper does not intend to provide independent evaluation or analysis of the GHG emission reduction or cost-effectiveness of policies, but rather to synthesize and organize policy options based on existing literature, documents and reports. The guidebook can also be used for low carbon development by local governments in other developing countries.

Low-Carbon Indicators

This study focuses on carbon, and defines a low-carbon city as a city that is actively and significantly lowering carbon emissions, even as its economy is maturing. Therefore the report gives guidance on the reduction of the two main carbon-based GHGs: carbon dioxide (CO_2) and methane (CH_4).[2] CO_2 emissions are primarily from energy consumption of fossil fuels, as well as from non-energy industrial processes (like cement production), and forest loss. Methane emissions arise from agriculture (especially rice production), animal husbandry, other land use, industry (e.g., coal-bed methane), and waste decomposition.

Indicators are used to define a low-carbon city, to help cities explore the gaps and potential for carbon emissions reduction, to evaluate progress in implementing low-carbon development actions, and to compare or benchmark across cities. Key indicators identified in the guidance document are shown in the table below.

Sectors	**Key Indicators**
Aggregated and mixed indicators	energy or carbon intensity of the economy, i.e., overall energy or CO2 per unit GDP, city greenhouse gas emission inventory
Aggregated relative indicators	energy or CO2 per capita or per land area
Structural indicators	sectoral shares of energy and GDP
Residential and commercial sector	energy or CO2 per floor area or per person/employee, percent compliance with building efficiency codes, Registered and certified LEED buildings, green buildings or other certification/capita, Installed capacity of integrated renewable or CHP in buildings/m2, space heating intensities
Industrial sector	physical efficiency (energy or carbon per ton of product); economic intensity (energy or carbon per unit value added)
Power sector indicators	CO2 per kWh share of renewables in electricity supply

[2] Note that a comprehensive emissions inventory would include all *six* GHGs recognized under the Kyoto Protocol: CO_2, CH_4, N_2O (from fertilizers and manure), SF_6 (from electrical systems, magnesium production), HFCs (refrigeration, semiconductor manufacturing, aluminum smelting), and PFCs (aluminum and semiconductor production).

Transportation	primary energy or CO2 per person-kilometer or ton-kilometer traveled; urban density; public transit use; kilometers of public transit per 100,000 population
Land Use and Waste Management	area share of mixed–use zoning (residential and commercial); percentage of landfill gas (methane) that is captured area share of green space and agricultural land; waste generated per capita; and recycling rate of waste.
Economic and Social Indicators	green jobs; income distribution and income per capita; and housing affordability.

Below are detailed description of the key indicators:

Aggregated:

- *Energy or CO2/GDP*

  The ratio of energy consumption, or carbon emissions, to gross domestic product (GDP) is used to measure the economic energy intensity of national economies. This is a key indicator used in China's 11^{th} and 12^{th} Five-Year Plans and announced internationally. An intensity indicator is appealing at the aggregate level, as it utilizes sets of data already tracked: energy, carbon, and GDP. However, this is a mixed indicator, accounting for both physical energy efficiency and economic structure that influences energy consumption. As economic development proceeds, the economic energy intensity typically declines, yet absolute energy and carbon still increase. Thus, there are significant limitations to this indicator and its use in target setting. Indicators distinctly focused on physical energy and carbon intensity, and on aspects of economic structure that affect energy consumption and carbon emissions, are encouraged instead.

- *Energy or CO2/capita*

  Because energy consumption and carbon emissions can be strongly influenced by the size of the population, per capita indicators provide a better and more equitable basis for comparison across cities, provinces, and countries. This indicator is widely used in China and internationally. Highly aggregated per capita indicators, such as total energy or CO2 per person, should be used with caution, however. A city with heavy industry and small population, which supplies other cities with cement and steel, would have high energy per capita. Yet the people of the city might use relatively little energy in their residences. Thus it is important to consider residential energy per capita, and the energy structure of a city, as well as total energy or CO2 per capita.

- *Energy or CO_2/land area*

  Another measure of the energy or carbon intensity of a city can be a spatial measure, such as density per land area. This indicator is less common, but is being examined as cities consider how density of development influences energy consumption and carbon emissions.

- *Economic Structure: sectoral shares of GDP (primary, secondary, tertiary)*

  Because different sectors of the economy have notably different energy and carbon intensity, economic structure is an important indicator of structural influences on consumption and emissions. Of many definitions of economic structure, the simplest and most often used in China is the share of primary, secondary, and tertiary sectors of the economy. The secondary sector represents industry and construction – the most energy intensive—while the tertiary sector represents commerce and service-focused businesses such as Information Technology (IT), communication services, health care, and energy saving services. Even this fairly aggregated indicator can help cities identify areas for low-carbon development.

- *Energy Structure: sectoral shares of energy consumption—industrial, residential, transport, other*

  Similar to an economic structure indicator, energy structure helps to identify areas needing extra attention for low-carbon development. Typical definitions of energy sectors include: industrial, residential, transport, agriculture and forestry, commercial, construction, etc. The first three sectors are the easiest to obtain data on; often the remaining energy sectors are grouped into "other energy." The industrial energy sector coincides with the secondary economic sector, while the others have overlap to different extents.

- *Overall renewable energy use, and share of renewable in total city energy*

  A key indicator of the carbon intensity of a city is the amount of renewable energy in the fuel mix. Renewable energy includes wind, solar thermal (for hot water), solar photovoltaic (for electricity), hydropower (with a distinction between large and small hydro), geothermal, and biomass. (Nuclear energy, although low carbon in operation, is not a renewable energy source.) This overall renewable energy indicator captures renewable that provide heat and transportation, as well as electricity. It is a well-defined indicator and helps a city clearly track progress toward low-carbon energy supply.

Buildings

- *Residential energy consumption or CO_2 emissions/capita (could be climate adjusted)*

  This indicator is commonly used to capture the energy efficiency of the building and home appliances, as well as behavior. If possible, it should be climate adjusted to exclude the influence on energy use induced by different climates. If climate adjusted, this indicator can be used for comparison with other peer cities. Weather variation can be accounted for by calculating cooling degree-hours (CDH) and heating degree-days (HDD).

- *Residential energy consumption or CO_2 emissions/m^2 (could be climate adjusted)*

  This indicator is similar to the per capita based intensity indicator, but targets building energy efficiency based on households without considering the number of people per household. Floor space data are available in the statistics in the form of m^2 per capita in urban and rural areas.

- *Commercial energy consumption or CO_2 emissions/m^2 (could be climate adjusted)*

  This indicator is commonly used for evaluating low energy and low carbon buildings. As with residential buildings, climate-adjusted values would more accurately reflect energy efficiency, taking into account the various heating and cooling demand among cities. Commercial and industrial floor space data may be collected through the local taxation office through property taxes. If data broken out by building types are available, then more detailed information and comparisons can be provided.

- *Energy/ electricity consumption per employee*

  In addition to the intensity in terms of energy use per unit of service floor area stated above (Commercial energy consumption or CO2 emissions/m^2), an alternative indicator is energy use per employee in the sector. Data on employee numbers may be easier to collect than m^2, providing an advantage for the use of this indicator. However, energy or electricity consumption per square meter is slightly more meaningful as energy use is generally based on floor space.

- *Registered and certified LEED buildings, green buildings or other certification/capita*

  The goal of LEED or green buildings is to increase the efficiency with which buildings use resources, energy, water and materials. More such certified buildings in a city would imply lower energy and lower emission. However, the selection of the certification/label scheme should be evaluated as in practice, a well certified building could use more energy compared to a similar building without it. Research also shows that the measured energy performance of LEED buildings has little correlation with certification level of the building, or the number of energy credits achieved by the building at the design phase (Newsham et al., 2009). Therefore the types of green certificates should be carefully assessed and selection should be based on verified actual savings that a certified building could deliver through measurement or tracking the change in utility bills.

- *Installed capacity of integrated renewable in buildings/m^2 (PV, solar water heaters, geothermal)*

  This indicator could demonstrate the cities' actions in reducing carbon emissions in buildings, not necessarily improving the efficiency of the buildings. Therefore, this indicator should be used in conjunction with other building efficiency measures that aim to reduce demand. By using the per m^2 basis, the indicator can avoid favoring large buildings and large cities.

- *Installed capacity of combined heat and power (CHP) in buildings*

  On-site generation with recovery of waste heat can improve the energy efficiency in electricity use in buildings from 40% to 80%, and significantly reduce the carbon emissions. Particularly it will be very effective to the fast growing city center where the expansion of existing centralized grid reaches its limit due to the already congested infrastructure. The installed capacity of CHP in buildings could help to define the building energy performance.

Industry

- *Share of coal in industrial fuel mix*

  This indicator measures the extent to which lower carbon fuels, such as natural gas or biomass, are used by industrial facilities. Some industries, like cement, can partially replace the use of coal in the kiln with natural gas and many other alternative fuels including agricultural and non-agricultural biomass (sewage sludge, paper sludge, waste paper).
- *Industrial economic energy or carbon intensity*

  This indicator is often used at a highly aggregated level, combining all industrial energy consumption (and carbon emissions) with value-added economic output from industrial activities. This indicator can also be used at a sub-sectoral level, for example, to compare the intensity of overall cement production in a city with the intensity of chemicals or steel production or other industrial sub-sectors. This can help a city identify development to promote or restrict, and help to benchmark with other cities.
- *Enterprise-level resource productivity*
  - Manufacturing energy use per unit of manufacturing value added GDP
  - Sales/CO_2 emissions
  - Production volume/CO_2 emissions

  Productivity efficiency ratios measure the outputs of an enterprise in relation to their carbon emissions impacts. Sales/CO_2 emissions measure resource productivity, and production volume/CO_2 emissions measures process eco-efficiency.
- *Physical energy or carbon intensity of key products produced*

  Physical energy or carbon intensity (vs. economic energy or carbon intensity using value added as the denominator) such as energy use or carbon emissions/t crude steel or cement is preferred because it is a more robust indicator of the level of energy or carbon efficiency of the production process.
- *CO_2 emissions per unit of manufacturing energy use and CO_2 emissions per unit of manufacturing GDP*

  Since the manufacturing sector is extremely diverse, the International Energy Agency (IEA) relies more heavily on economic indicators such as energy use per unit value added, to be able to compare trends across manufacturing sub-sectors.

Electric Power

- *CO_2 emissions per unit of generated electricity*

  The amount of CO_2 equivalent emissions per unit of generated electricity is a common indicator for tracking de-carbonization of electricity supply. Expressed as tCO_2eq/kWh or tCO_2eq/TWh, this indicator helps to track the reduction of the use of carbon-intensive coal, and the fostering of renewable power generation as well as generation from natural gas and nuclear. This indicator also serves as an emission factor for determining carbon emissions from electricity use.
- *Share of renewable sources in electricity supply; GW of operating renewable capacity*

  The share of renewable sources in electricity supply is an indicator often used to track progress with Renewable Portfolio Standards (RPS). While the CO_2eq/TWh is an indicator of net carbon in electricity, the share of renewable energy highlights the most sustainable energy sources. As the absolute amount of energy consumption changes, it is also useful to track the absolute amount of renewable generation capacity that is installed and actually operating. Wind farms cannot reduce carbon emissions if they are not sending power to the grid, so it is important to know and count the operational status of renewable energy sources.

Land Use and Waste Management

- *Waste per capita (disposed, diverted)*

  The amount of waste per person is an indicator of the resourcefulness of the city's people; less waste means more efficient use of resources. Waste contains embodied energy and carbon, materials, and pollutants. By reducing the amount of waste generated—and disposed—per person, a city can save resources. Reducing the amount of waste going to landfill also reduces emissions of methane (a potent GHG) from the decomposition of organic waste in landfills.
- *Recycling, and overall diversion rate of waste away from landfills*

  For any waste that is generated, there is still the possibility of recycling, composting, or otherwise diverting the waste from disposal. For most wastes, there is a net energy and carbon saving from recovering the waste. Tracking the recycling and/or diversion rate is a widely used indicator at the city and enterprise level.
- *Percentage of landfill gas (methane) that is captured*

  For any waste that does end up in a landfill, there is one last option for recovering energy and reducing carbon emissions: landfill gas capture. Landfill gas is primarily methane; thus it can be captured to avoid methane emissions, and also utilized as a fuel, thereby replacing the use of a more carbon-intensive fuel such as coal.
- *Agricultural Land - Hectares of food production, and share of agriculture in total area*

  The amount of agricultural production within city (or county) boundaries is important to low-carbon development for two main reasons. The first is that local food production can lower energy and carbon, by reducing transport and refrigeration needed to provide food for the city. The second is that some types of agricultural production, notably rice production, can generate methane emissions; management practices can be used to reduce those emissions. Other types of food production provide short-term sequestration of carbon. An important added benefit to local food production is that it supports local farmers, provides jobs, and better connects urban dwellers to the source of their food.

Transport

- *Primary energy or CO_2/vehicle-km*

  This indicator provides a measure of the average fleet efficiency of all vehicles in a city. Calculating this indicator requires knowing the total trip length of all public transportation modes (subway, bus, street cars) in addition to total trip length of all private transport (cars and taxis), as well as the total trip length of all trucks (light, medium, and heavy duty), as well as the total energy consumption of these vehicles. It could alternatively be estimated from a calculation of the average fleet efficiency (by vehicle type) in MJ/km along with the annual vehicle kilometers travelled by vehicle type.
- *Primary energy or CO_2/person-km*

  This indicator provides a measure of the energy or carbon intensity of moving people around a city. Calculating this indicator is challenging, since it requires knowing the turnover (passenger-kilometers) of all public transportation modes (buses, light rail, subway, etc), and estimating the total person-trip-kilometers for all private travel in cars and taxis, as well as the total energy consumption of these travel modes.
- *Primary energy or CO_2/ton-km*

  This indicator provides a measure of the energy or carbon intensity of moving goods to and around a city. Calculating this indicator is challenging since it requires knowing the total freight turnover of a city (in ton-km) and the energy consumption of the vehicles used for freight delivery.
- *Kilometers of high capacity public transit systems per 100,000 population*

High capacity public transit (such as bus rapid transit, BRT) facilitates movement of large numbers of people typical of morning and evening commute hours. The more extensive the system, the higher likelihood that commuters will choose this mode of travel over less efficient modes

- *City resident public transit use (number of public transit trips per capita)*

  The degree to which residents choose to ride public transportation in their total annual travel reflects both the accessibility and desirability of public transportation as well as results in lower transportation energy consumption and road congestion compared to use of personal cars. Data on total kilometers of travel in personal cars are generally not available, but surveys can provide a baseline of total personal travel by mode.

- *Urban density*

  Higher density land use is strongly correlated with lower per capita energy and resource consumption. For transportation, higher density allows for greater access to public transportation, reduces transit network length, and reduces the need for private cars. Urban density can be measured in terms of population per square kilometer, excluding parks and designated open space; as the number of dwelling units per square kilometer; or as a floor area ratio of the total floor area of buildings divided by the total land area used.

- *Share of each city's alternative-fueled (hybrid, CNG, EV, NG) vehicles of the total vehicle fleet (government and private, buses, cars, trucks)*

  City governments often own and operate a fleet of vehicles, including cars, trucks, buses, and specialized vehicles, running on gasoline and diesel. This indicator measures the number of these vehicles that run on alternative fuels with lower emissions than standard internal combustion engines.

- *Two-wheeled vehicle ownership per capita*

  Two-wheeled vehicles, including conventional bicycles, e-bikes, and motorcycles, offer some of the highest energy efficiencies of urban transportation modes. Registration data should be available for motorcycles and e-bikes.

Creation of a Low Carbon Development Plan

The preceding examination of indicators provides cities with a way to define and track low-carbon development. These indicators can be incorporated into a development plan or action plan. Essential steps[3] that are commonly used in the creation of a low-carbon development plan are:

1. Leadership Commitment

   The first essential step is commitment by the city's leadership. With the city's attention turned to low-carbon development, and sufficient staff and time and resources committed to the effort, the city can successfully develop and implement its low-carbon plan.

2. Conduct Energy and Carbon Emissions Inventory

   a. Identify the main sources of energy and carbon
   b. Identify options for energy and carbon savings (rough analysis)

   Two main emission sources are CO_2 and CH_4. CO_2 comes primarily from energy consumption of fossil fuels, as well as from non-energy industrial processes (like cement production), and forest loss. CH_4arises from agriculture (especially rice production), animal husbandry, other land use, industry (e.g., coal-bed methane), and waste decomposition.

   The emissions inventory is a best estimate of emissions from activities in the city or province – not a precise measurement. The emissions inventory covers sources of CO_2 and CH_4 from the following sectors: electric power, industrial, residential, commercial, transportation, land management (agriculture and other land use, rural and urban), and waste.

[3] Based on steps developed by ICLEI; for example, ICLEI 2009.

Scope of the Inventory. Since some emission-generating activities may cross city boundaries, it is important to clearly define the scope of the emissions inventory, to know what emissions get counted by the city. Internationally-recognized inventory protocols have defined three emission scopes: (1) direct, (2) indirect, and (3) associated emissions. Table 1 explains what emissions are included under each scope.

Table 1. GHG Emissions Inventory Scope

Emissions Scope	Scope Acitivities
Scope 1: Direct Emissions: Generated Within City Boundaries	Direct Energy Consumption within the City (fuel for Industry, Heating, Cooling, Electricity generation, Infrastructure, etc.) Transportation within the City Land Use and Waste Management within the City
Scope 2: Indirect Emissions: Due to Activities Within City Boundaries, Generated Outside City Boundaries	Import of Electricity and Heating used in the City
Scope 3: Associated Emissions: Due to City Activities, Occuring Across or Outside City Boundaries	Intra-regional Transportation City Waste in Landfills outside the City

Source: Clean Air-Cool Planet, 2010.

Data Needs. City staff preparing the carbon emissions inventory must work with the local and provincial statistical bureau, with utilities supplying electricity to the city, with transportation and waste agencies, as well as enterprises. The basic emission sources and data needed are summarized in Table 2. The energy and other data on emission sources and activities, combined with emission factors, yield a GHG emissions inventory.

Table 2. Data Needs for a Greenhouse Gas Emissions Inventory

Sector	Data on emission sources
Electric Power	Energy mix and amount of generation: kWh from coal, natural gas, oil, hydro, wind, solar, nuclear, etc.
Industrial	Electricity and fuel (natural gas, coal, heat, others) consumption
Residential	Electricity and fuel (natural gas, coal, heat, others) consumption Building floor space and type
Commercial	Electricity and fuel (natural gas, coal, heat, others) consumption Building floor space and type
Transportation	Electricity and fuel (gasoline, diesel, others) consumption Mix of Transport Modes (feet, bicycle, motorbike, bus, light rail, train, auto, truck) Vehicle Efficiencies (Fuel Economy) for each mode Vehicle Miles Traveled (VMT) on local roads, for each mode VMT on highways (related to the jurisdiction)
Land Use	Hectares of food production, by type (rice, wheat, etc.) Numbers of cattle, pigs, horses Hectares of Forest cover (existing, removed, added)
Waste	Total landfill waste (tonnes) Typical composition of waste (organic matter, plastics and other non-degradable material, land-cover materials)

3. Set Targets
    a. Forecast energy, carbon, and GDP under different scenarios (Business-As-Usual, Savings Scenario)
    b. Set targets based on scenario forecasts

c. If time is available, set targets based on detailed analysis of potential savings, policies and measures (see next step)

Target setting involves choosing the **type** of target, and the target **value**. Targets need to be measurable and reportable, so that progress toward goals can be tracked. A physical target is preferable—such as total CO2 emissions, or energy use, or amount of wind energy—because it can be measured and has a direct influence on the health of the city and province. Economic targets are also important. The target value is set by projecting energy and carbon in scenario analysis (Business-As-Usual Scenario, and Savings Scenario), and evaluating the impact of potential policies.

4. Create a Low-Carbon Development Plan (Climate Action Plan + Low-Carbon Economic Plan), with Policies and Actions to Meet Targets
    a. Analyze and select policies and actions (detailed analysis, including co-benefits, costs, and savings)
    b. Clearly state the goals for each action and how progress will be measured
    c. Choose **Policy Mechanisms** (Action Plan) to help meet provincial targets

   The savings potential from the policies will depend on that province's situation (e.g., baseline inventory, mix of efficiencies in building stock, etc.). The cost in the province will depend on that province's situation (e.g., energy pricing, renewable energy resources), as well as a typical unit cost. How can a city choose which policies it needs to meet its Target? First conduct a **rough review** of potential policies and actions, qualitatively considering estimates of savings and costs. Next, choose a shorter list of actions for **detailed**, **quantitative analysis**. Closely connect the actions to the Emissions Inventory and Scenarios, addressing each sector of the economy. Also consider input from research institutes, the community, businesses, and government officials.

5. Implement Policies and Actions
    a. Identify and allocate responsibility
    b. Set aside funding for implementation
    c. Set timetables
    d. Support policies with incentives, penalties, training and public outreach

6. Monitor, Report and Verify Progress

   Progress must be tracked with **Monitoring**, including **Reporting** and **Verification**. Reporting on intensity must include data on energy use, carbon emissions, and data on economic activity, to verify the resulting intensity number. Public reporting of data, along with progress toward goals, focuses attention and effort from government, enterprises, and the public, and helps to achieve the targets. City government websites are an effective means for publicly tracking progress on energy, carbon, and low-carbon economic development.

The guidance here focuses on the city level; similar steps can be undertaken at every level, from enterprise, to city, province, and country.

Policies and Actions to Achieve Low Carbon Development

Because the heart of a low-carbon development plan is its actions, the guidebook provides an extensive list of policy options and performance indicators. International experience demonstrates that end-use energy efficiency has the capability to significantly reduce GHG emissions at low cost. Because energy and economic structures vary from city to city, the impact of the policies and associated costs need to be evaluated in order to determine priorities and to assist the local governments to select most cost effective policies. This report intends to provide basic indicators and methods of policy choice by categorizing them into “High, “Medium”, “Low” in terms of the energy and carbon savings, and similar categorization in terms of implementation costs. Examples of such policy categories and their significance in the building and industry sectors are shown in Table 3 and

Table 4, and Figure 1 and Figure 2, respectively. The tables list the policy options, noting the rough scale of energy and carbon savings, as well as costs to implement. The figures highlight the significance of policy options by graphically ranking them. A quantified cost-benefit analysis of policies would further facilitate policy prioritization and implementation by local governments. More detailed analysis also requires more public datasets and survey results. The guidebook includes policies and actions to achieve low-carbon growth in the following sectors: cross-cutting (not focused on a specific end-use sector), industry, buildings, transportation, power, agriculture and forestry. For each policy or action identified in each sector, the following information is included, where available:

- Description
- Performance metric
- GHG emission reduction potential
- Cost-effectiveness

The policies draw on international examples, including both national and state or provincial level measures. Chinese approaches are also included if they are considered to be successful or innovative. An excerpt from one policy for the industrial sector – target setting – is provided below to illustrate the format and content of the policies included in the guidebook.

Target Setting[4]

Policy Description

Target-setting for energy efficiency or GHG emissions reduction is a common practice; a recent survey identified 23 such programs in 18 countries around the world, including countries in Europe, the U.S., Canada, Australia, New Zealand, Japan, South Korea, and Chinese Taipei (Taiwan) (Price, 2005). Targets are typically either voluntary commitments or negotiated agreements, but can also be mandatory targets assigned by the government as in the case of China’s Top-1000 Energy-Consuming Enterprises Program. Targets can be agreed upon by individual companies or by industrial sectors through organizations such as industrial associations. Voluntary commitments are often made by companies either individually or through government programs. The U.S. Environmental Protection Agency’s (EPA’s) Climate Leaders is comprised of approximately 200 companies that have committed to undertake a corporate-wide inventory of their GHG emissions, set aggressive reduction targets, and report their progress annually to the EPA (U.S. EPA, 2010a). Voluntary commitments are also made by industrial sectors such as the Cement Sustainability Initiative (CSI) of the World Business Council for Sustainable Development (WBCSD) (CSI, n.d.; WBCSD, 2010) and the International Aluminium Institute (IAI, 2009).

Performance Metrics

There are three performance metrics for target-setting programs:

1. The number of enterprises with target-setting contracts
2. The number of enterprises that meet or surpassed their targets
3. The average savings per participating enterprise

GHG Emission Reduction Potential

[4] See the guidebook for the references provided in this section.

GHG emissions reductions by U.S. EPA Climate Leaders companies are estimated to be equivalent to more than 50 $MtCO_2e$ per year (U.S. EPA, 2010b). Given that there are 195 companies currently in the program, this is an annual average emissions reduction of approximately 256,000 tCO_2e per company.

The UK Climate Change Agreements have also resulted in large CO_2 emissions reductions. During the first target period (2001-2002) total realized reductions were nearly three times higher than the target for that period (Future Energy Solutions, 2004). Industry realized total reductions that were more than double the target set by the government during the second target period and that were nearly double the target during the third and fourth target periods (AEA Energy & Environment, 2009; DEFRA, 2005; DEFRA, 2007; Future Energy Solutions, 2005). There are approximately 9000 facilities participating in this program. If the annual emissions reductions of 20.3 $MtCO_2$ achieved in 2007 and 2008 are divided evenly among these 9000 plants, the average emissions reductions are 2255 tCO_2/plant/year.

In November 2009, China's National Development and Reform Commission announced that the Top-1000 program had surpassed its target energy savings of 100 Mtce, saving 106 Mtce by the end of 2009 (NDRC, 2009). Dividing this savings over 5 years by the roughly 1000 participating enterprises results in annual savings of 20,000 tce per plant. Using a conversion factor of 2.5 tCO_2/tce results in estimated average annual per plant savings of 5,000 tCO_2.

Cost-Effectiveness

A 2004 evaluation of the first Dutch Long Term Agreements (LTA1s) calculated that the cost of the LTA1s was about $10 per tonne of CO_2 reduced, assuming the savings last for 10 years and using a social discount rate of 5% (Blok et al., 2004). Sweden's program for improving energy efficiency in energy-intensive industry was introduced after the adoption of an electricity tax in 2004. In 2006, 98 companies submitted reports outlining nearly 900 energy-efficiency improvements that they plan to undertake by 2009 which will cost the companies about €110 million and reduce electricity consumption by 1 TWh/year, saving companies €55 million per year. In addition, the companies will receive €17 million tax reductions through this program (SEA, 2005; SEA, 2006; SEA, 2007).

In 2007, the UK's National Audit Office found that in general the benefits of the Climate Change Agreements (CCAs) outweighed the program administrative costs (NAO, 2007). An independent evaluation of the CCA program found that in addition to the energy and GHG emissions reductions, the program provided "positive macroeconomic effects in economic terms, with small increases in GDP and employment" (Barker et al., 2007). It is estimated that UK industry saves over $800 million per year as a result of meeting the UK CCA targets (Pender, 2005), an average annual savings of over $90,000 per year for the approximately 9000 participants. Another analysis estimated that the benefit net costs per ton of carbon saved in 2010 from the CCAs will be $38/$tCO_2$ (DEFRA, 2006).

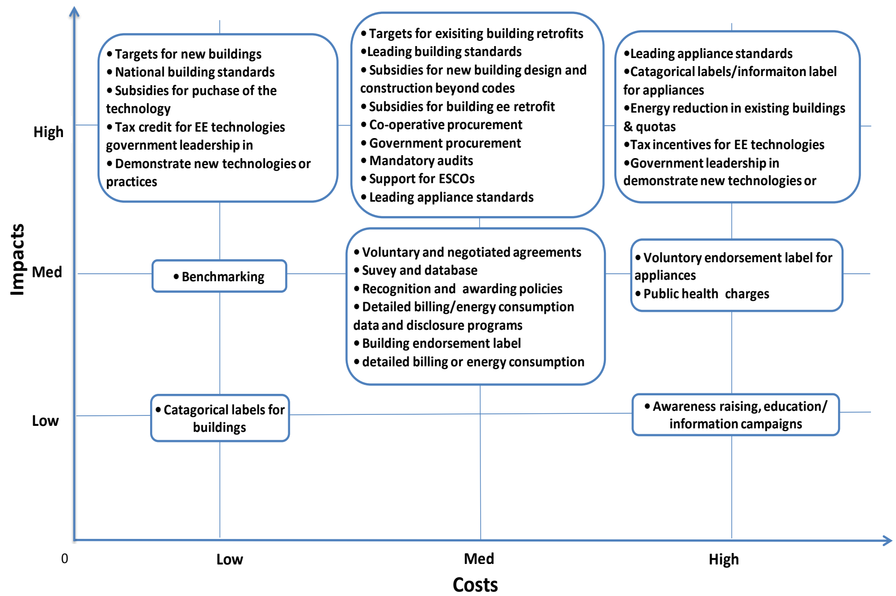

Figure 1 Costs and Savings of Energy Efficiency Policies for Buildings and Appliances

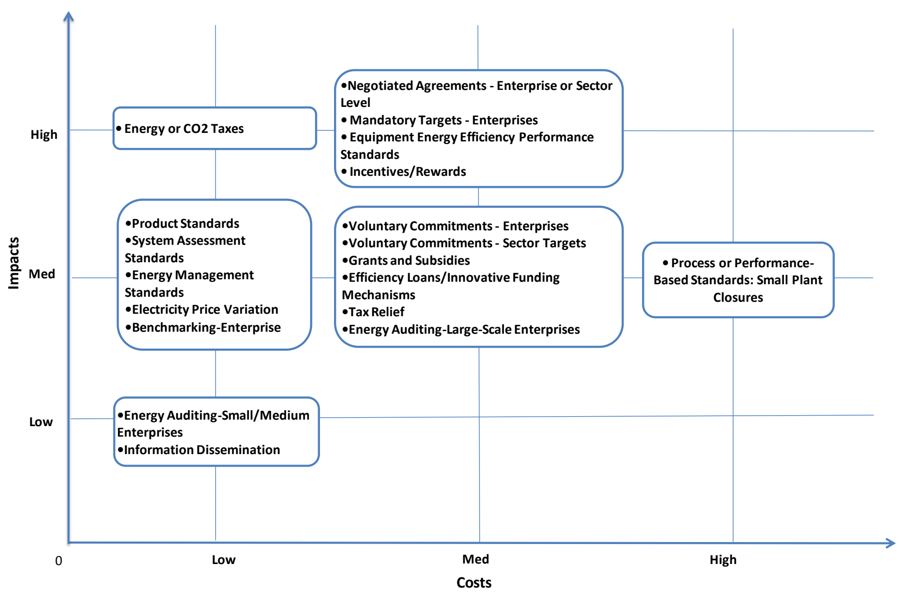

Figure 2. Costs and Savings of Energy Efficiency Policies for Industry

Table 3. Examples of Policies and Programs for Building Sector

Policy/Program Identification		Cost and Impact						
Policy Option	Performance Metric	GHGs Reduction by 2020			COST			Notes
		Hi	Med	Lo	Hi	Med	Lo	
Targets								
Targets for new buildings	Inspection and evaluation on compliance	X					X	both at design and construction phase
Targets for existing building retrofit	m2 retrofitted	X				X		
Standards								
National Building Standards	Level of building codes; compliance level	X					X	
National Appliance Standards	Level of standard; compliance level	X				X		
Certification, Labels, Voluntary Programs								
Appliance Categorical/information label	Level of compliance; product grade market shift	X			X			
Voluntary endorsement label for appliances and buildings	Level of compliance; product grade market shift		X		X			effective with financial incentives, voluntary agreements and regulations
Energy management								
Energy reduction in existing buildings	Coverage; compliance level	X			X			
EE Technology/measure Promotion								
Subsidies for building ee retrofit	Retrofitted area	X				X		
Tax credit/incentives for EE technologies	Increased sales in EE technologies	X			X		X	low cost for tax credit
Setting technology dissemination goals	MW installed							
Zoning								
Mixed-use Zoning; green space zoning	Area regulated; stringency of requirements	X						
Public Sector Leadership								
Government procurement	clear and accessible information, compliance level	X				X		
Building Commissioning/Auditing								
Mandatory audits	Number of audits conducted	X				X		most effective if combined with other measures such as financial

								incentives
Reporting								
Detailed billing or energy consumption data and disclosure programs	Data availability		X				n. a	success conditions: combination with other measures and periodic evaluation.

Table 4. Policies and Programs for Industry Sector

Policy/Program Identification		**Cost and Impact**					
Policy Option	**Performance Metric**	**GHGs Reduction by 2020**			**Cost**		
		Hi	**Med**	**Lo**	**Hi**	**Med**	**Lo**
Targets							
Voluntary Commitments - Enterprises	Average savings per participating enterprise; # of enterprises with targets; # of enterprises that meet or surpassed targets		X			X	
Voluntary Commitments - Energy-Saving and GHG Emission Reduction Sector Targets	Achieved savings/emissions reductions		X			X	
Negotiated Agreements - Enterprise or Sector Level	Average savings per participating enterprise; # of enterprises with targets; # of enterprises that meet or surpassed targets	X				X	
Mandatory Targets - Enterprises	Average savings per participating enterprise; # of enterprises with targets; # of enterprises that meet or surpassed targets	X				X	
Standards							
Product Standards	Energy saved and/or CO2 emissions reduced annually		X				X
System Assessment Standards	Energy saved and/or CO2 emissions reduced annually		X				X
Process or Performance-Based Standards: Equipment Energy Efficiency Performance Standards	Sector reaches "advanced minimum"	X				X	
Process or Performance-Based Standards: Small Plant Closures	Final/primary energy saved per t cement; final/primary energy saved per t iron; final/primary energy saved per t steel; electricity saved per kWh; final/primary energy saved per t paper; final/primary energy saved per t aluminum		X		X		
Energy Management Standards	Information on standards disseminated to industry; standards adopted		X				X
Fiscal/Financial Instruments							
Energy or CO2 Taxes	Benefit net of costs per ton CO2 saved	X					X
Grants and Subsidies	Energy saved and/or CO2 emissions reduced per unit of funding provided		X			X	
Energy Efficiency Loans and Innovative Funding Mechanisms	Energy saved and/or CO2 emissions reduced per unit of funding provided		X			X	
Tax Relief	Energy saved and/or CO2 emissions reduced		X			X	

Electricity Price Variation			X				X
Incentives/Rewards	Energy saved and/or CO2 emissions reduced	X				X	
Energy Auditing							
Large-Scale Enterprises	# energy audits conducted; typical savings identified/audit		X			X	
Small and Medium Enterprises	# energy audits conducted; typical savings identified/audit			X			X
Benchmarking							
Enterprise Level	# enterprises undertaking benchmarking; Energy saved and/or CO2 emissions reduced as a result of benchmarking		X				X

Conclusion

Much work lies ahead to appropriately define and implement low-carbon development at the city level. China has announced the goal to achieve lower carbon intensity and to develop low carbon demonstration cities. Even so, there is still a strong need for methodologies, measures, and tools to achieve these goals. This paper, and the guidebook upon which it is based, provides an important foundation for these efforts. The low carbon indicators examined here provide clear metrics for tracking energy and carbon savings over time, as well as comparing progress among cities. The planning steps outlined in the paper can help cities shape a comprehensive effort and aim for climate-friendly city development. Finally, the policy options and categorization illustrated in this paper provide guidance for cities to take action.

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