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Energy-Efficiency and Greenhouse Gas Mitigation Policy Options: Assisting Chinese Cities in Prioritizing and Choosing Strategies to Implement to Become a Sustainable Community

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ABSTRACT

Myriad energy-efficiency and greenhouse gas mitigation policy options are available for urban communities to reduce energy use and emissions from buildings, transportation systems, industries, utilities, public lighting, water and wastewater, and solid waste disposal. This paper describes a methodology to assist urban community planners and policymakers in China to prioritize and choose strategies to implement for their particular situation. The methodology was developed for use in a dynamic decision-making tool, the Benchmarking and Energy-Saving Tool for Low Carbon Cities (BEST-Cities), which was specifically designed for urban communities in China but which could be used internationally. The methodology builds on concepts from other urban low-carbon planning tools, but augments them to address specific Chinese conditions and needs. The methodology starts by conducting a simple inventory of energy use by end-use sector, which is then converted by the tool into units of carbon dioxide and methane emissions. Next, Key Performance Indicators are calculated and the tool benchmarks the city to other cities, providing an indication of the energy saving and emissions reduction potential for each end-use sector as a first step for policy prioritization. Then the level of authority and capacity of the city in terms of financial and human resources and enforcement is self-assessed since these are also important inputs for policy prioritization. The tool then provides Chinese planners and policy-makers with a menu of policies and measures prioritized by sector based on the identified energy and emissions reduction potential and distinguished by speed of implementation, carbon savings potential, and first cost to the government. Planners and policymakers then prioritize the policy options based on their specific criteria and needs.

Introduction

Cities around the world are implementing policies and programs with the goal to reduce greenhouse gas emissions, as well as to save energy, reduce costs, and protect the local, regional, and global environment. In China, low-carbon development is a key element of the 12th Five Year Plan, which covers the period 2011-2015. Pilot low-carbon development zones have been initiated in five provinces and eight cities and many other locations around China also want to pursue a low-carbon development pathway. The key steps for cities pursuing low-carbon development include undertaking an energy and carbon inventory, identifying potential energy and carbon savings opportunities, and setting specific energy or carbon emissions reduction

goals or targets. Then comes the task of choosing strategies and policies to achieve the targets. Analysis of progress in low-carbon development among Chinese cities has shown that much work remains in choosing and implementing policies across city sectors, and that further guidance and tools would be helpful in this regard (Khanna et al. 2014)

A dynamic decision-making tool called the Benchmarking and Energy-Saving Tool for Low-Carbon Cities (BEST-Cities) was developed by the China Energy Group at Lawrence Berkeley National Laboratory to provide city authorities in China with strategies they can follow to reduce city-wide carbon dioxide (CO_2) and methane (CH_4) emissions. The tool assesses local energy use and energy-related CO_2 emissions across nine sectors (i.e., industry, public and commercial buildings, residential buildings, transportation, power and heat, street lighting, water & wastewater, solid waste, and urban green space), giving officials a comprehensive perspective on their local carbon performance. Cities can also use the tool to benchmark their energy and emissions performance to other cities inside and outside China, and identify those sectors with the greatest energy saving and emissions reduction potential.

Another important feature of BEST-Cities is its ability to help Chinese city authorities evaluate the appropriateness of more than 70 different strategies that can reduce their city's energy use and emissions. The 70 strategies include both policies and programs that are already in existence in China as well as policies and programs that are used internationally but have not yet been adopted in China. These 70 strategies are described in detail in the tool, but cannot be described in this paper due to space constraints. By identifying those strategies most relevant to local circumstances, the tool helps local government officials develop a low carbon city action plan that can be implemented in phases, over a multi-year timeframe.

This paper describes the BEST-Cities methodology to assist urban community planners and policymakers in prioritizing and choosing which strategies to implement for their particular situation. BEST-Cities was specifically designed for urban communities in China but could also be used internationally if modified to address data availability, energy and currency units, and other country or region-specific conditions. The paper concludes with a discussion of next steps in terms of beta-testing the model with Chinese data and providing training in its use in China.

Background

China's 12th Five Year Plan (2011-2015) includes a carbon intensity target to reduce CO_2 emissions per unit of GDP by 17% over the planning period. This target is further allocated to China's provinces and cities through binding contracts. In order to promote significant policy and programmatic actions to reach these targets, pilot low-carbon development zones have been initiated in five provinces and eight cities.

A review of existing tools and methodologies for assessing city-level energy use and emissions and for providing policy and program recommendations was undertaken to determine if such a program or software existed that could be introduced in China in support of the carbon intensity target and low-carbon development plans. Six low carbon planning tools were reviewed: 1) Greenhouse Gas Emissions Software (Torrie Smith, 2013), 2) the Global Protocol for Community-Scale Greenhouse Gas Emissions (WRI and WBCSD, 2013), 3) Climate Compass (Climate Alliance, 2013), 4) the Emerging and Sustainable Cities Initiative (IDB, 2013), 5) Sustainable Urban Energy Planning: A Handbook for Cities and Towns in Developing Countries (UN-Habitat, UNEP and ICLEI, 2009), and 6) Tool for the Rapid Assessment of City Energy (TRACE) (World Bank, 2013). The review assessed whether these tools included energy and carbon benchmarking, energy savings and emissions reduction policy options, prioritization

of policy options, and evaluation support. The review found that none of the tools included all of these components and none was available in Chinese or included Chinese energy units.

The review did, however, determine that many features of the World Bank Energy Sector Management Assistance Program's (ESMAP's) TRACE tool would be a useful basis for development of a tool for China. The TRACE diagnostic tool is used to benchmark city energy use, prioritize sectors with significant energy savings potential, and identify energy efficiency actions in the areas of transport, buildings, water and waste water, public lighting, solid waste, and power and heat.[1] As a result, the developers of BEST-Cities worked closely with the developers of TRACE to build upon the experience and incorporate the logic of TRACE into the new tool. BEST-Cities differs from TRACE in that it has expanded the list of sectors to also include industry (manufacturing) and urban green space and to break buildings into public/commercial buildings and residential buildings. In addition, BEST-Cities uses Chinese energy units (e.g. tons of coal equivalent, tce) and is available in both English and Chinese.

BEST-Cities was developed as a key component of the work that Lawrence Berkeley National Laboratory is undertaking related to low carbon, eco-city urban development in China. This work, which is funded by both the U.S. Department of Energy and the Energy Foundation China, has been on-going since 2010 and has involved understanding international eco-city theory, indicators, and case studies (Williams et al., 2012;Zhou and Williams, 2013) as well as development of low-carbon indicators (Price et al. 2011; Price et al., 2012a; Price et al. 2012b), low-carbon eco-city tools (He et al., 2013), and low-carbon guidebooks for policy-makers (Zhou et al., 2011a; Zhou et al., 2011b; Zhou et al., 2011c; Zhou et al., 2011d; Zhou et al., 2013).

BEST-Cities Methodology

BEST-Cities has three main components: (1) Inventory and Benchmarking, (2) Sector Prioritization, and (3) Policy Analysis. Whereas other tools may focus on energy but not carbon, or provide a policy database but not a prioritization mechanism, the BEST Cities methodology combines these components to facilitate development of a low carbon action plan.

Inventory and Benchmarking

The Inventory and Benchmarking component of the tool has three sections: 1) City & Sector Data, 2) Energy & Carbon Inventory, and 3) Benchmark Results. For the City & Sector Data section, the user is asked to input city-wide information on population, total primary energy consumption, total greenhouse gas (GHG) emissions, gross domestic product (GDP), the city's climate zone, the city's Human Development Index (HDI), and the share of industry and service sector GDP. The user is also asked to input annual energy consumption data by fuel for each of the nine end-use sectors in the tool: Industry, Public & Commercial Buildings, Residential Buildings, Transportation, Power & Heat, Public Lighting, Water & Wastewater, Solid Waste, and Urban Green Space. BEST-Cities has been designed to consider data availability in China. Much of the required data is available to city authorities in local statistical yearbooks or through other sources. Once the data are entered, the tool generates the city's Energy & Carbon Inventory, providing final energy use and CO_2 emissions for each of the nine end-use sectors. Since the user enters fuel consumption in physical units (e.g. metric tons of coal consumed), this section uses fuel energy conversion factors from China's National Bureau of Statistics (NBS,

[1] See: https://einstitute.worldbank.org/ei/course/trace-how-use-tool-rapid-assessment-city-energy

2011) and uses CO_2 emissions factors from the Intergovernmental Panel on Climate Change (IPCC, 1996; IPCC 2006). China-specific carbon sequestration conversion coefficients (EC, 2012) and energy unit conversion factors for power and heat by Province are used (NBS, 2011).[2]

Next, BEST-Cities provides benchmark results, comparing the city-wide and sector-specific Key Performance Indicators (KPIs) to those of other cities in China. BEST-Cities provides benchmarks for a total of 33 KPIs, reported as ratios so that they can be easily compared across cities. Table 1 highlights some of the indicators for each city sector, as well as city-wide indicators on energy, carbon, and the economy. One indicator per sector (in **bold** text) is designated as "Representative" and used later to estimate the improvement potential and priority policies for each sector. Figure 1 shows an example of benchmarking for a city-wide indicator – GHG Emissions Per Capita (tCO_2e/person) – for the city of Jinan compared to other cities of a similar population size, from a database of 288 Chinese cities. (The data for Jinan are shown in yellow). To conduct meaningful benchmarking, the BEST Cities tool allows for filtering of comparator cities by Population, Climate Zone, Human Development Index (HDI), and Industrial share of GDP. Due to the heavy industrial base of Jinan's local economy and its high consumption of coal, the city ranks quite high in per capita GHG emissions.

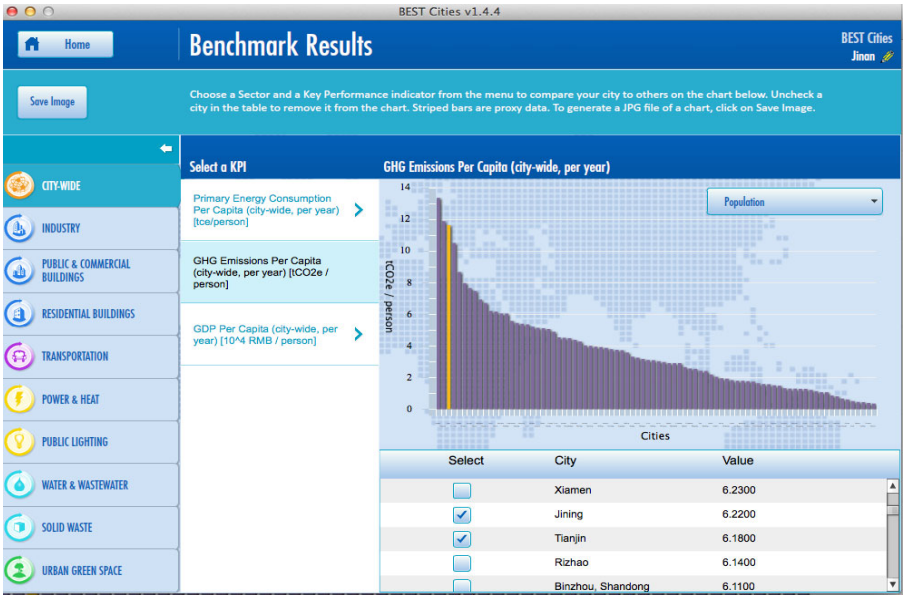

Figure 1. BEST-Cities benchmarking: GHG emissions per capita (tCO_2e/person).

[2] Due to data limitations, emissions calculations are based on production – not consumption - for both power generation and heat. For electricity, the conversion factor is based on total fuel consumption for power generation within a province divided by total electricity output. For a province with a substantial power imports, the production-side calculations may over- or understate the emissions factor of power consumed depending on the origin of the imported electricity. For heat, such issues are unlikely, since there is not long distance trade of heat.

Table 1. Key performance indicators for low-carbon Chinese cities

KPI #	KPI Name	Unit of measure
City-wide		
CW01	Primary Energy Consumption per capita (city-wide, per year)	tce/person
CW02	GHG Emissions per capita (city-wide, per year)	tCO_2e/person
CW03	GDP per capita (city-wide, per year)	10^4 RMB/person
Industry		
IN01	**Industrial Economic Energy Intensity** (Final Energy consumption/unit industrial value added)	tce/10^4 RMB
IN02	**Industrial Carbon Intensity** (GHG emissions/unit of industrial value added)	tCO_2e /10^4 RMB
IN03	**Share of Fossil Fuel in Industrial Energy** (excluding heat and electricity)	%
IN04	**Share of Electricity Use in Industrial Energy**	%
Public and Commercial Buildings		
BL01	**Public buildings electricity intensity**	kWh/m2
BL03	**Share of Green Buildings** (% of city-wide floor space designated as "Green" building or similarly labeled building)	%
Residential Buildings		
BL02	**Residential buildings energy use per capita**	tce/person
Transportation		
TR01	**Transportation energy use per capita**	tce/person
TR04	**Mode share of public transit** (% of trips by bus and rail)	%
Power & Heat		
PH01	**Share of Renewable Energy in local electricity supply**	%
Street Lighting		
SL01	**Electricity Intensity of Street Lighting** (Grid-connected electricity consumed per km of lit roads per year)	kWh/km
SW01	**Municipal solid waste disposed per capita** (per year)	kg/person
Water & Wastewater		
WW01	**Water consumption per capita** (per year)	m3/person
WW02	**Electricity intensity of potable water supply**	kWh/m3
WW03	**Energy intensity of Wastewater treatment**	tce/10^4 m3
Urban Green Space		
UG01	**Urban Green Space per capita**	m2/person

Sector Prioritization

The next step is sector prioritization, which identifies those sectors with the highest potential for energy saving and carbon emissions reductions. This component has three sections: 1) Sector Improvement Potential, 2) City Authority, and 3) Sector Prioritization Results.

Based on the earlier benchmarking results, BEST-Cities estimates the Sector Improvement Potential for one "Representative" KPI for each sector. For example, for residential buildings, the Representative KPI is residential buildings energy use per capita and for the power and heat sector the Representative KPI is the share of renewable energy in the local electricity supply. The BEST-Cities sector improvement potential value is calculated as:

$$\text{Sector Improvement Potential [\%]} = \frac{KPI_{City} \quad KPI_{average\ better}}{KPI_{City}} \qquad \text{(eq. 1)}$$

where the $KPI_{average\ better}$ is the mean of the values of all chosen peer cities with better performance. In the Residential Building sector of Jinan, for example, if ten peer cities used less energy per capita in residential buildings than Jinan (i.e., the ten peer cities performed "better" than Jinan), the improvement potential is the difference between the average value of those ten peer cities' residential energy per capita, and that of Jinan, divided by the residential energy per capita in Jinan, The improvement potential is a simple, rough estimate, for the purpose of selecting policy strategies to pursue for energy and carbon savings. If the user desires, the calculated potentials can be overridden based on their knowledge of the actual savings potentials in each sector.

It is important to understand the level of authority the city (or other relevant jurisdiction) has to enact and implement policies and programs. The City Authority section of the tool asks the user to indicate the level of control city authorities have (between 0% and 100%) for each of the nine sectors covered by BEST-Cities. Definitions of the level of control are shown in Table 2.

Table 2. BEST-Cities city authority level of control definitions

Level of Control	**% Control**	**Description**
National Stakeholder	1-5%	Policy is formulated at the national level in consultation with municipal governments.
Provincial Stakeholder	5-30%	Policy is formulated at the provincial level in consultation with municipal governments on issues outside of its jurisdiction.
Multiple Agency Jurisdiction	30-50%	Municipal government has some control of one or more aspects of the sector (regulatory and budgetary) but will need to work with other agencies to introduce change.
Policy Formulator	50-75%	Municipal government is responsible for formulating policy or local regulations but may not have an enforcement role.
Budget Control	75-90%	Municipal government has full financial control over the provision of services, purchase of assets, and development of infrastructure, but it may lack some enforcement role or powers.
Regulator/Enforcer	90-100%	Municipal government has strong regulatory control over the sector and is able to create and enforce legislation, and where possible sanction those entities out of compliance.

Next, BEST-Cities provides Sector Prioritization Results, which ranks each sector based on the Sector Improvement Potential, the magnitude of CO_{2e} emissions, and the sector City Authority assessment. The overall sector Score is determined by the following calculation:

Sector Improvement Potential (%) x Sector CO_2 Emissions (10^4 tCO_2e) x City Authority (eq. 2)

The Sector Prioritization Results assist the user in deciding which sectors to focus on given the potential for savings, the level of energy use or emissions, and the degree to which the user has the authority and associated financial, policy-making, regulatory, and enforcement capability.

Policy Analysis

The Policy Analysis component of BEST-Cities assists the user in identifying policies and programs for energy saving and carbon emissions reduction across the nine sectors in the target city. BEST-Cities contains a database of more than 70 policies and programs (drawn from international and Chinese policy experience) that can be adopted at the city level in China (see Table 3). The information provided for each policy or program includes a description, implementation strategies and challenges, monitoring metrics, case studies, and attributes including the carbon savings potential, first cost to the government, the speed of implementation, and any related co-benefits such as reduction of pollutant emissions, reduced water use and waste, improved air quality, enhanced public health, increased productivity, and energy and cost savings for enterprises.

The Policy Analysis component of the methodology is comprised of five sections: 1) City Capability, 2) Policy Appraisal, 3) Policy Review, 4) Policy Matrix, and 5) Priority Policies. In addition to the authority level of the city, it is important to understand the capability of the city in terms of project finance, human resources, and policy, regulation, and enforcement (see Table 4). In the City Capability section, the user is asked to rank the city's capabilities in these areas for each of the nine sectors.

The Policy Appraisal section ranks policies based on the results of the assessment of the capabilities of the city in terms of project finance, human resources, and policy, regulation, and enforcement in each prioritized sector, comparing each policy's minimum requirements against the observed levels of capabilities and opportunity in the city. The color-coding of appraisal results works on the simple traffic light system: green indicates good compatibility, yellow marginal compatibility, and red poor compatibility. The initial appraisal is undertaken to give guidance to the city; it is not prescriptive and it is the responsibility of the city to determine which policies will be taken further.

The Policy Review section displays all policies selected through the Policy Appraisal along with their attributes: Speed of Implementation, Carbon Savings Potential, and First Cost to Government. The estimated range of values for these policy attributes are from the BEST-Cities database, based on the size of the city, or any override values the user entered.

Table 3. BEST-Cities Policies and Programs

Sector	Policy/Program	Sector	Policy/Program
Industry	Benchmarking	Transportation	Bicycle Path Networks
	Energy Audit / Assessments		Bike Share Programs
	Industrial Energy Plan		Clean Vehicle Programs
	Stretch Targets for Industry		Complete Streets
	Incentives and Rewards for Industrial Energy Efficiency		Vehicle CO_2 Emission Standards
	Industrial Energy Efficiency Loans and Innovative Funds		Mixed-Use Urban Form
	Tax Relief		Integrated Transportation Planning
	Energy or CO_2 Tax		Public Transit Infrastructure: Light Rail, BRT, and Buses
	Industrial Equipment and Product Standards		Parking Fees and Measures
	Differential Electricity Pricing		Public Education on Transport Options
	Energy Management Standards		Vehicle License Policies
	Energy Manager Training		Commuting Programs
	Recycling Economy and By-product Synergy Activities		Vehicle Fuel Economy Standards
	Low-carbon Industrial Parks		Congestion Charges, and Road Pricing
	Fuel-switching		Bicycle Path Networks
Public & Commercial Buildings	More Stringent Local Building Codes	Power & Heat	Minimum Performance Standards for Thermal Power Plants
	Green Building Guidelines for New Buildings		Load Curtailment Incentives/Demand Response/Curtailable Rates
	Expedited Permitting for Green Buildings		Power Investment subsidies and tax incentives for Renewable Energy
	Targets for Efficient and Renewables in Buildings		Time-based Electricity Pricing Schemes: Inclining Block Pricing and Time-of- Use Pricing
	Building Energy Labeling and Information Disclosure		Transformer Upgrade Program
	Mandatory Building Energy-Efficiency Audit		District Heating Networking Maintenance and Upgrade Program
	Public Education Campaigns on Building Energy Efficiency and Conservation		Renewable Energy and Non-fossil Energy Targets or Quotas

Sector	Policy/Program	Sector	Policy/Program
	Municipal Building Energy Efficiency Task Force	Public Lighting	Public Lighting Plan
	Energy Performance Contracting and Energy Service Companies		Audit and Retrofit Programs
	Retrofit Subsidies and Tax Credits for Existing Buildings	Water & Wastewater	Public Education Measures
	Subsides for New Buildings that Exceed Building Code		Methane Capture and Reuse/ Conversion
	City Energy and Heat Maps		Active Leak Detection and Pressure Management Program
	Cooperative Procurement of Green Products		Prioritize Energy Efficient Water Resources
	Financial Incentives for Distributed Generation in Buildings		Facility Operator Training Program
Residential Buildings	Reach Standards for Efficient Appliance and Equipment		Water Management Plan
	Building Workforce Training		Improve Efficiency of Pumps and Motors
	Green Building Guidelines for New Buildings		Codes, Consumer Education, and Incentives for Water-Efficient Products
	More Stringent Local Building Codes		Public Education Measures
	City Energy and Heat Maps	Solid Waste	Recycling and Composting Mandate and Program
	Building Energy Labeling and Information Disclosure		Landfill Methane Recovery
	Targets for Efficient and Renewables in Buildings		Integrated Solid Waste Management Planning
	Expedited Permitting for Green Buildings		Waste Composting Program
	Retrofit Subsidies and Tax Credits for Existing Buildings		Waste Vehicle Fleet Maintenance, Audit and Retrofit Program
	Subsides for New Buildings that Exceed Building Code		Anaerobic Digestion
	Energy-Efficient Equipment and Renewable Energy Technology Purchase Subsidies		Public Education Program
	Public Education Campaigns on Building Energy Efficiency and Conservation	Urban Green Space	Urban Green Space
			Urban Forestry Management

Table 4. BEST-Cities City Capability Definitions

Area	City Capability	Description
Finance	Low	Funding is available from municipal budget streams only. Municipal government has no experience of other financial or partnering mechanisms.
	Medium	Municipal government has some experience with grants, soft loans, and commercial financing instruments.
	High	Municipal government has relevant experience in innovative financing mechanisms, such as performance contracting, ESCO partnerships, and carbon financing, in additional to grants, soft loans, and commercial financing instruments.
Human Resources	Low	Municipal government has few technically skilled staff and/or a small available workforce. Staff must be trained/or workforce expanded to deliver any new low carbon projects.
	Medium	Municipal government has access to a highly trained/skilled person to lead the initiative and/or a medium sized workforce available. Additional staff and/or training may be necessary to deliver any new low carbon projects.
	High	Municipal government has access to a sufficient number of trained/technically proficient staff resources, including skilled planners/modelers.
Policy, Regulation, Enforcement	Low	Municipal government is responsible for master or strategic planning, but engagement with other agencies is weak. Municipal government has limited capacity to regulate at the local level. Enforcement is weak.
	Medium	Municipal government has the ability to regulate local activity in this sector. Enforcement is in need of strengthening, however.
	High	Municipal government is responsible for all regulatory standards and policies. Municipal government has enforcement powers, which it uses effectively.

The Policy Matrix shows all recommendations from the prioritized sectors sorted by First Cost and CO_2 Emissions Reduction Potential (see Figure 2). The check boxes allow the user to alter the display based on their preferences for Speed of Implementation. In the example of Jinan, the policies with low cost and high carbon savings potential include "Reach" Standards for Efficient Appliances and Equipment, for the Residential Buildings sector, since that sector has a fairly large potential for improvement, and because the city capabilities for implementing policy in that sector are sufficient for this particular policy (appliance standards). The highest priority policies are found in the upper right cells of the matrix (color-coded with bright green) in Figure 2.

Finally, the Priority Policies section of the tool shows the city's prioritized list of low-carbon policies, based on data and analysis by the BEST-Cities tool. The user can click on a policy name to see details (Description, Implementation Strategies, Metrics, Case Studies, and Attributes). All Policies are saved in html and can be printed separately using the export function.

Figure 2. Policy matrix of prioritized strategies for energy and carbon saving.

BEST-Cities Outreach and Next Steps

In November 2013, the beta version of BEST-Cities was demonstrated to Director Jiang Zhaoli (Department of Climate Change, National Development and Reform Commission, NDRC), members of China's Macroeconomic Institute, and members of NDRC's Energy Research Institute. The feedback received was that the tool embodies NDRC's requirements for low carbon pilot cities, including conducting a carbon inventory across sectors, developing action plans, accounting for structural adjustment, placing an emphasis on fairness among cities and sectors, encouraging institutional innovation, and providing guidance for implementation. The reviewers felt that BEST-Cities is a very comprehensive and easy-to-use tool and Director Jiang highly recommended that it be widely promoted and used in cities across China.

Next, beta-testing of the tool using data from Jinan, the capital city of Shandong Province, was conducted to ensure that the tool functioned correctly and tested whether the policy recommendations were correctly filtered and prioritized by the tool. The results are documented in He (2014). The application of the tool shows that industry dominates the city's energy and emissions and followed by buildings sector, and overall Jinan is in the middle of the major indictors compared to peer cities of a similar population size or in the same climate zone. Sector prioritization shows that the industry, public and commercial buildings, and transportation sectors have the largest potential for energy savings and emissions reductions. Policies such as an energy tax, more stringent building codes, appliance standards, a fuel economy standard, and a CO_2 emissions standard could be implemented to assist Jinan's low carbon development.

Following the beta-testing in Jinan, BEST-Cities was introduced at a three day training workshop (March 5-7, 2014) for the Technology Development Strategy Institute of Shandong Academy of Science, Jinan, Shandong Province, China.[3] The training included an introduction to the principals, methodology, and functions of BEST-Cities, a presentation of a case study for Jinan, and a presentation on cost effective, energy saving and carbon emission reduction policies by sector (i.e. industry, building, power, transport, waste, water and urban green space). The opinions and judgment of the workshop participants on required BEST-Cities inputs related to Jinan's city authority and competence to implement a certain policy in terms of finance, human resources, and policy regulation and enforcement were solicited. Based on the inputs, the case study for Jinan was revised and finalized. In the process, the audience also gained a clear understanding of the functions, data requirements, and outputs of BEST-Cities.

The workshop audience expressed a strong interest in using BEST-Cities for a number of applications. Next steps in the collaboration with the Shandong Academy of Science related to using and promoting BEST-Cities may include: 1) conducting additional case studies in cities in different economic development phases and with different economic structures (potential case cities include Dongying, Weifang and Guiyang), 2) ranking the low carbon development performance of 19 prefecture-level cities in Shandong province, 3) helping the Shandong Academy of Science organize wide-spread training workshops on BEST-Cities for related research institutes in Shandong Province and throughout China, 4) combining the functions of BEST-Cities with LBNL's Green Resources & Energy Appraising Tool (GREAT) for Cities in order to facilitate development of low carbon action plans for local governments such as Weifang, a pilot city in the U.S.-China Low Carbon Eco-City program, and later to all prefecture-level cities in Shandong Province, and 5) working with NDRC and its research institutes to carry out a large-scale roll-out of the tool training and dissemination to the whole country to assist in achieving the country's multiple initiatives related to developing low carbon/ eco/sustainable/new energy cities, as well as the achievement of their energy and carbon emission reduction goals.

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[3] Shandong Province is the largest emitter of CO_2 of all of China's provinces.

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