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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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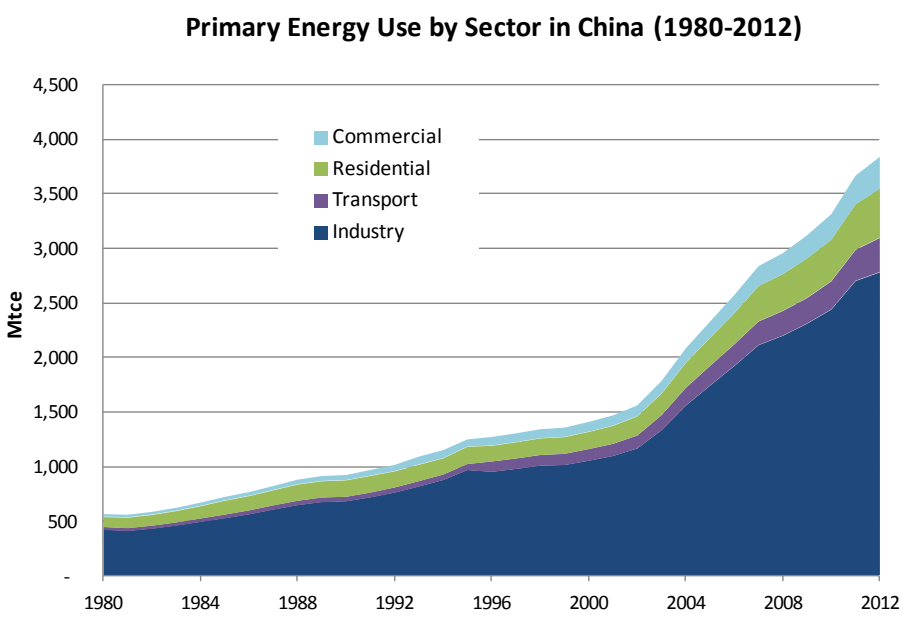
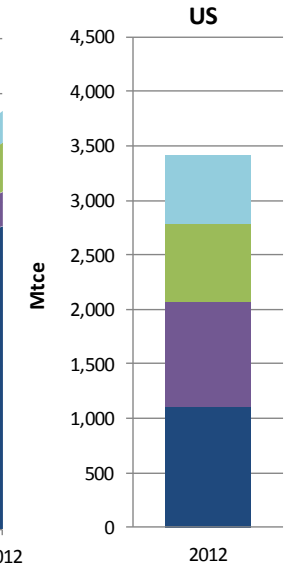
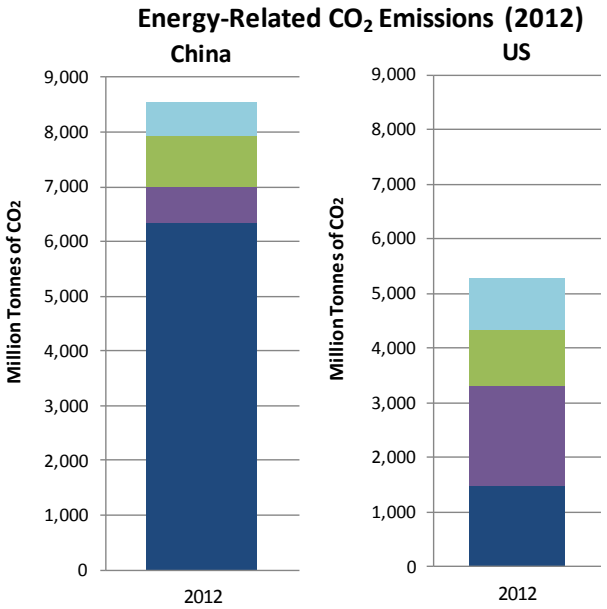
ACEEE Summer Study on Energy Efficiency in Buildings
August 18 , 2014

China's Energy Use and CO_2 Emissions

- 2009/10: China became the world's largest energy consumer
  - ~70% of China's primary energy use is coal
  - ~70% of China's electricity is coal-based
- 2006/07: China became the world's largest emitter of energy-related CO_2



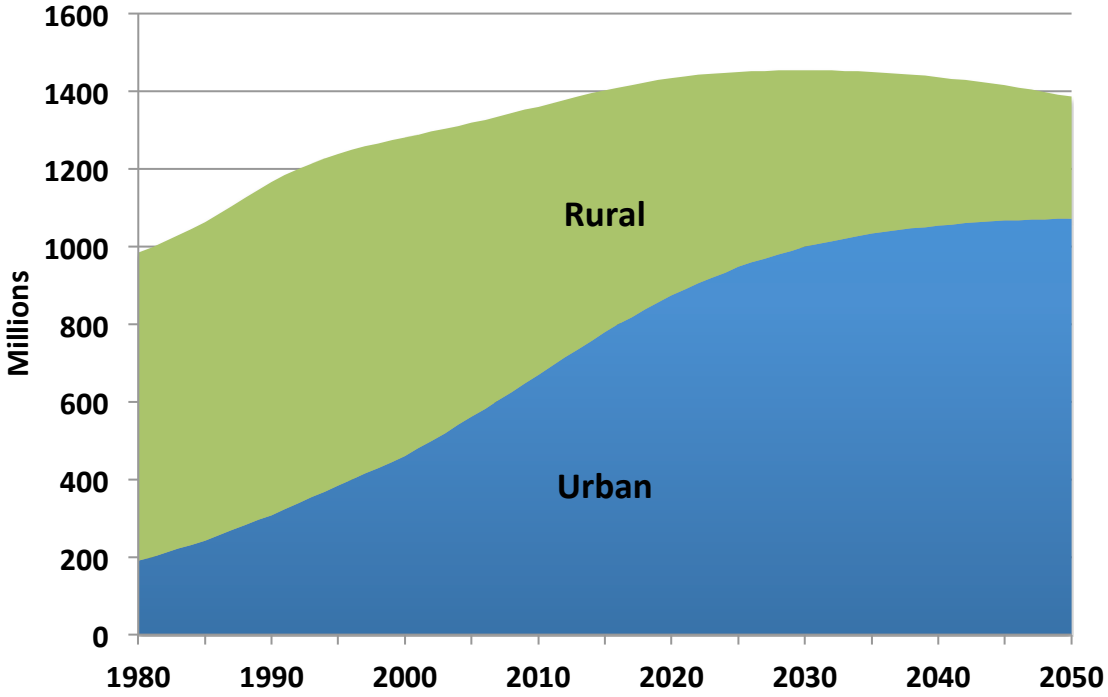




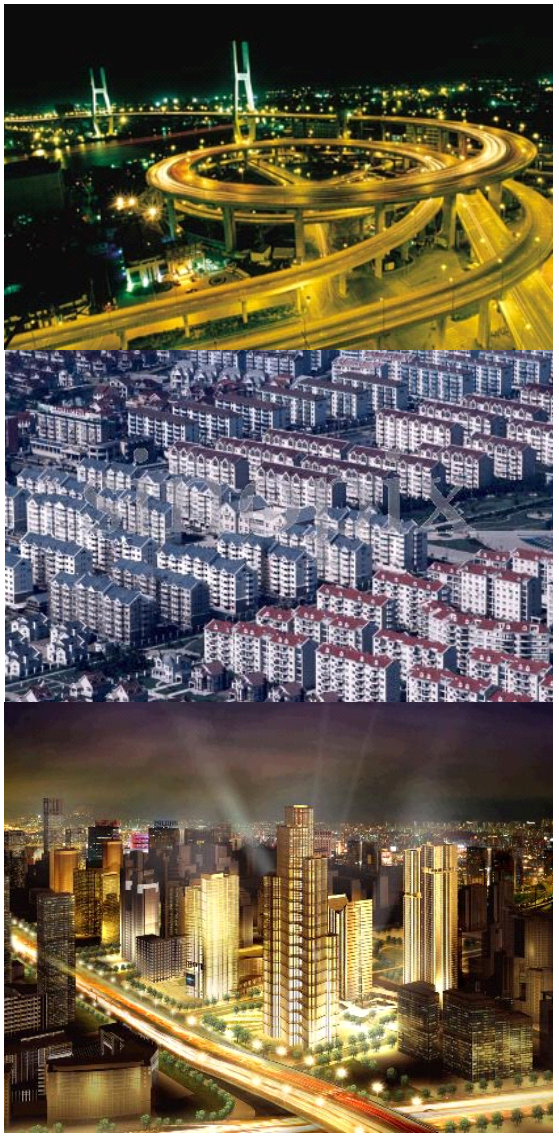
Source: NBS, 2013. China Statistical Yearbook.
Note: Mtce >> EJ = 0.0293; EJ >> Quads = 0.9478

China's Urbanization Trends

- China's urban population growth:
  - About 20% of the total population in 1980
  - About 50% in 2010
  - Expected to be about 80% in 2050



Source: United Nations, Department of Economic and Social Affairs, Population Division (2013). World Population Prospects: The 2012 Revision.



China's Energy and Carbon Targets

- China's energy and carbon commitments
  - 11th Five Year Plan energy intensity target
  - Domestic announcement and Copenhagen Accord
  - 12th Five Year Plan energy and carbon intensity targets
- China's low carbon development pilots
  - 2010:
    - 5 provinces: Guangdong, Liaoning, Hubei, Shaanxi, Yunnan
    - 8 cities: Chongqing, Tianjin, Shenzhen, Xiamen, Hangzhou, Nanchang, Guiyang, Baoding
  - 2012:
    - Increased to a total of 6 provinces and 36 cities

Review of Existing Low Carbon Tools

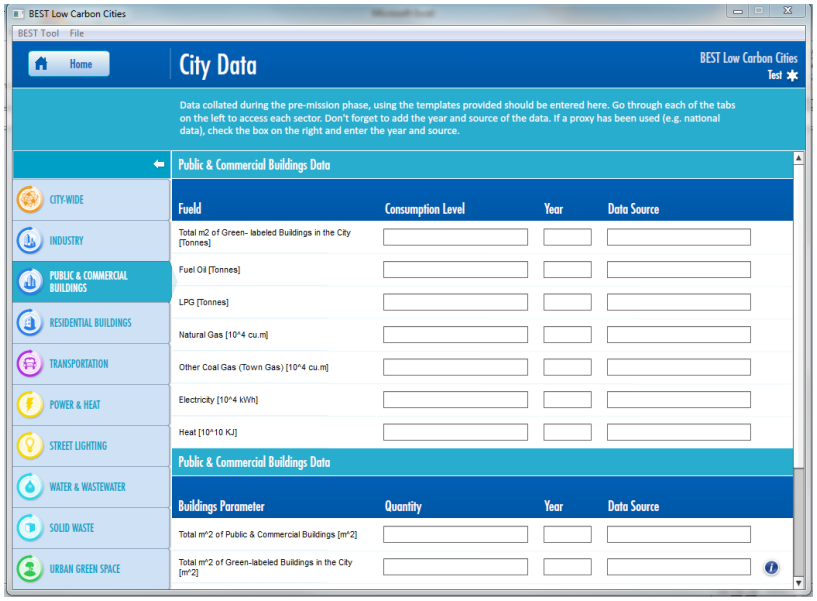
- Seeking a tool for energy/carbon inventory, benchmarking, energy/carbon policy options, energy/carbon savings, and policy prioritization
- Six existing low carbon urban planning tools were reviewed
- World Bank's Tool for the Rapid Assessment of City Energy (TRACE) developed by World Bank's Energy Sector Management Assistant Program (ESMAP)
  - Includes energy inventory, benchmarking, energy savings potential, prioritization, actions in 6 end-use sectors
  - Doesn't include carbon, industrial sector (which is predominant in Chinese cities), indicators and actions not necessarily applicable to Chinese situation
  - Requires on-the-ground consultants to implement = slow speed of dissemination/adoption

Benchmarking and Energy Saving Tool for Low Carbon Cities (BEST-Cities)

- Development funded by Energy Foundation China; training and dissemination funded by EF China and U.S. Department of Energy
- Developed in collaboration with World Bank experts, drawing from methodology and experience with TRACE, and China's Energy Research Institute
- Considers Chinese data availability
- Chinese energy units
- Available in English and Mandarin
- Citywide data plus 9 sectors:
  - Industry
  - Public & Commercial Buildings
  - Residential Buildings
  - Transportation
  - Power & Heat
  - Public Lighting
  - Water & Wastewater
  - Solid Waste
  - Urban Green Space

Benchmarking and Energy Saving Tool for Low Carbon Cities (BEST-Cities)

City & Sector Data



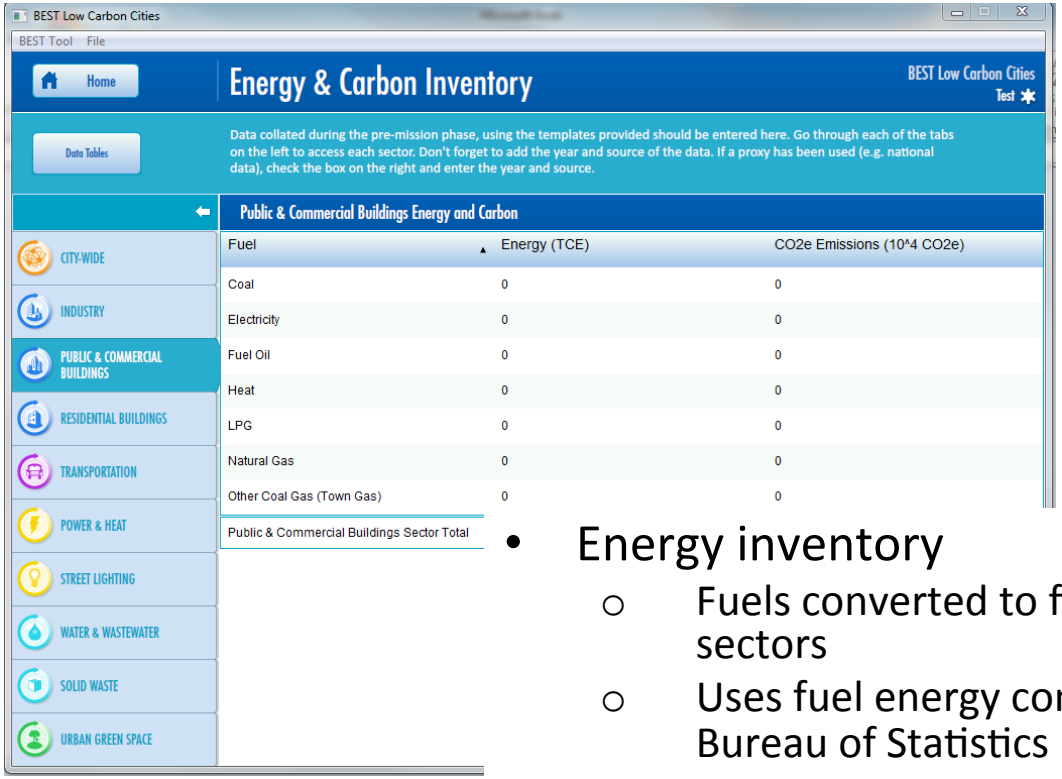
City Data

- Population
- GDP
- Climate zone
- Primary energy consumption
- GHG emissions
- Human Development Index
- Share of industry and service sector GDP

Sector Data

- Annual energy consumption by fuel for 9 sectors in physical units (e.g. metric tons of coal consumed)

Energy & Carbon Inventory



- Energy inventory
  - Fuels converted to final energy use for city and 9 end use sectors
  - Uses fuel energy conversion factors from China's National Bureau of Statistics
  - Reports in Chinese energy units
- Carbon inventory
  - Fuels converted to CO_2 emissions for city and 9 end use sectors
  - Uses CO_2 emissions factors from the IPCC
  - Reports in metric tons of CO_2

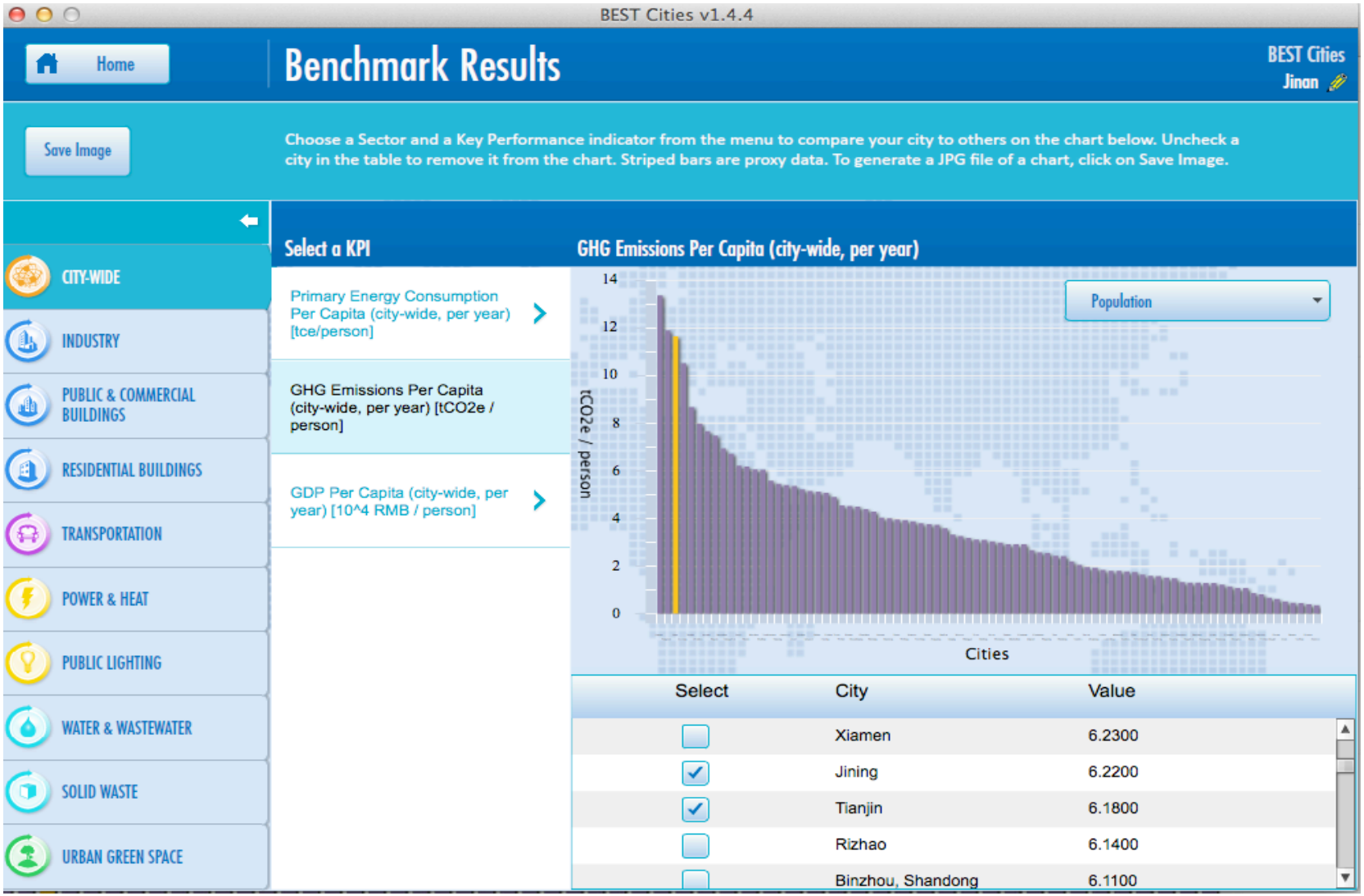
Benchmarking: 35 KPIs Citywide and in 8 Sectors

Sector	KPI Name
Citywide	Total citywide primary energy consumption per capita (per year) (tce/person)
Citywide	Total city wide GHG emissions per capita per year (tCO_2/capita/yr)
Citywide	Total citywide GDP per capita per year (10^4/capita/yr)
Industry	**Final energy consumption per unit industrial value added (tce/10^4 RMB)**
Industry	Total GHG emissions per unit of industrial value added (tCO_2/10^4 RMB)
Industry	Share of fossil fuel in total industrial energy consumption (not including heat and power) (%)
Industry	Share of electricity in total industrial energy use (%)
Industry	Final energy consumption per tonne of steel production (tce/tonne)
Industry	Final energy consumption per unit of building materials value-added (tce/RMB)
Industry	Final energy consumption per tonne of cement production (tce/tonne)
Industry	Final energy consumption per tonne of flat glass production (tce/tonne)
Industry	Final energy consumption per tonne of synthetic ammonia production (tce/tonne)
Industry	Final energy consumption per unit of textile sector value-added (tce/RMB)
Industry	Final energy consumption per tonne of ethylene production (tce/tonne)
Industry	Final energy consumption per unit of food sector value-added (tce/RMB)

Benchmarking: 35 KPIs Citywide and in 8 Sectors

Sector	KPI Name
Public & Commercial Buildings	**Public buildings electricity intensity (kWh/m^2)**
Public & Commercial Buildings	% of citywide floor space in ”green” buildings or other labeled buildings (%)
Public & Commercial Buildings	Total installed capacity of integrated renewable or CHP in public buildings (kW)
Public & Commercial Buildings	District heating supplied by cogeneration facilities (%)
Residential Buildings	**Residential buildings energy intensity (tce/capita)**
Transportation	**Transportation energy use per capita (per year) (tce/capita)**
Transportation	Public transit network (km/km^2)
Transportation	Mode share of non-motorized transport (%)
Power & Heat	**Share of renewable energy in local electricity supply (%)**
Street lighting	**Grid-connected electricity consumed per km of lit roads per year (kWh/km/yr)**
Water & Wastewater	Annual water consumption per capita (L/capita/yr)
Water & Wastewater	**Electricity density per unit of potable water supply (kWh/m^3)**
Water & Wastewater	Electricity density per unit of waste water treatment (kWh/m^3)
Solid waste	**Municipal solid waste diposed per capita per year (kg/capita/yr)**
Urban green space	**Urban green space per capita (m^2/capita)**

Benchmarking

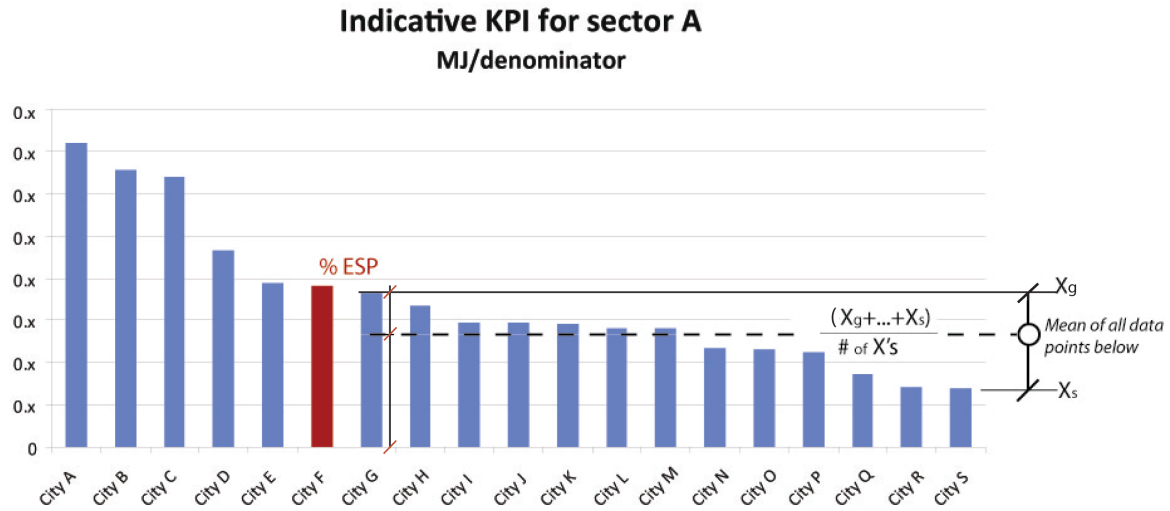


BEST-Cities Benchmarking: GHG Emissions Per Capita (tCO_2e/person)

Benchmarking and Energy Saving Tool for Low Carbon Cities (BEST-Cities)

Sector Prioritization: Sector Improvement Potential

- Sector Prioritization Formula: **[Sector Improvement Potential]** x [Carbon Emissions] x [City Authority]
- **Sector Improvement Potential** calculation is based on a single **"indicative" KPI** thought to best represent the sector.



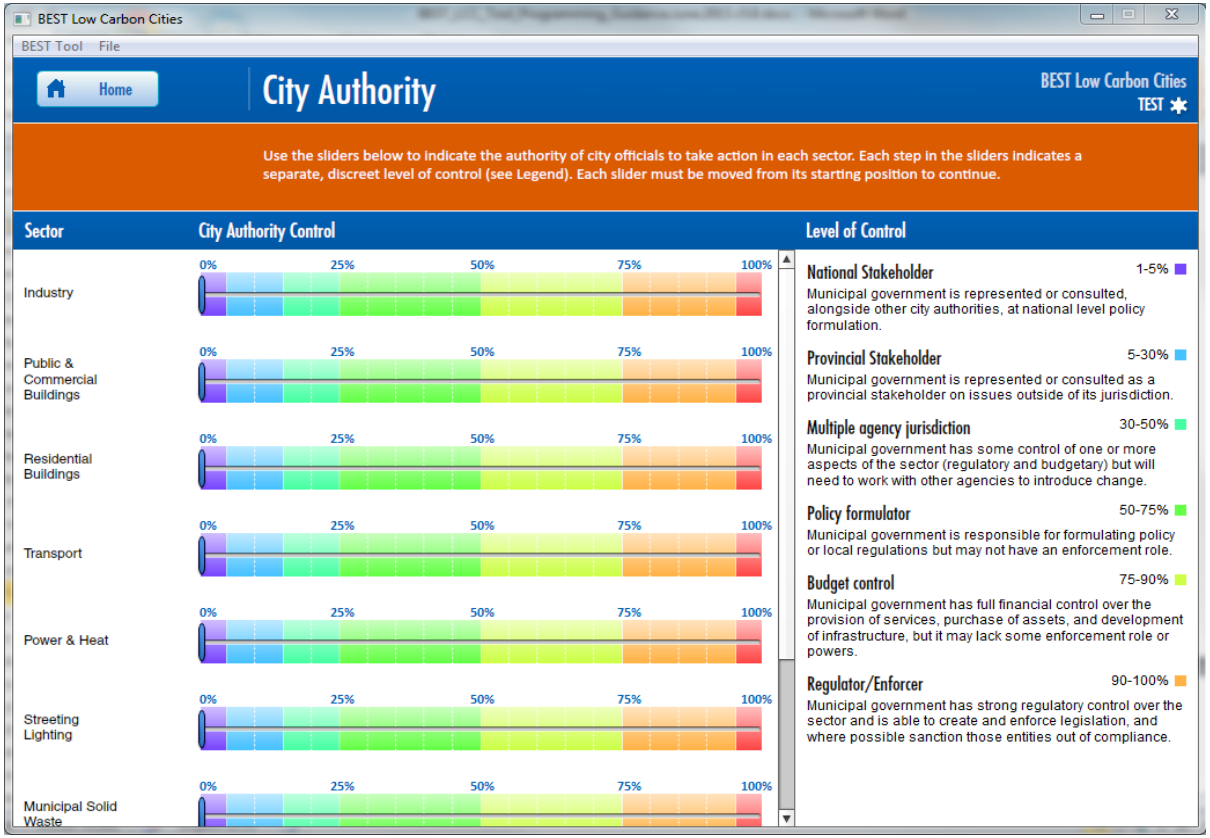
Equation for each sector KPI:

$$\text{Sector Improvement Potential [\%]} = \frac{\text{KPI}_{\text{City}} - \text{KPI}_{\text{average better}}}{\text{KPI}_{\text{City}}}$$

$$\text{Where } \text{KPI}_{\text{average better}} = \frac{\sum KPI_{\text{equal to or better than the city being benchmarked}}}{\#\ of\ cities\ equal\ or\ better}$$

Sector Prioritization: City Authority

- Sector Prioritization Formula: [Sector Improvement Potential] x [Carbon Emissions] x **[City Authority]**
- **City Authority:** a weighting factor designed to reflect the level of policy control that local authorities can exert over a given sector



Sector Prioritization: Overall Score

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Sector Prioritization Results

BEST Cities
CITY B

9 of 9
selected

The list below shows the priority ranking of 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

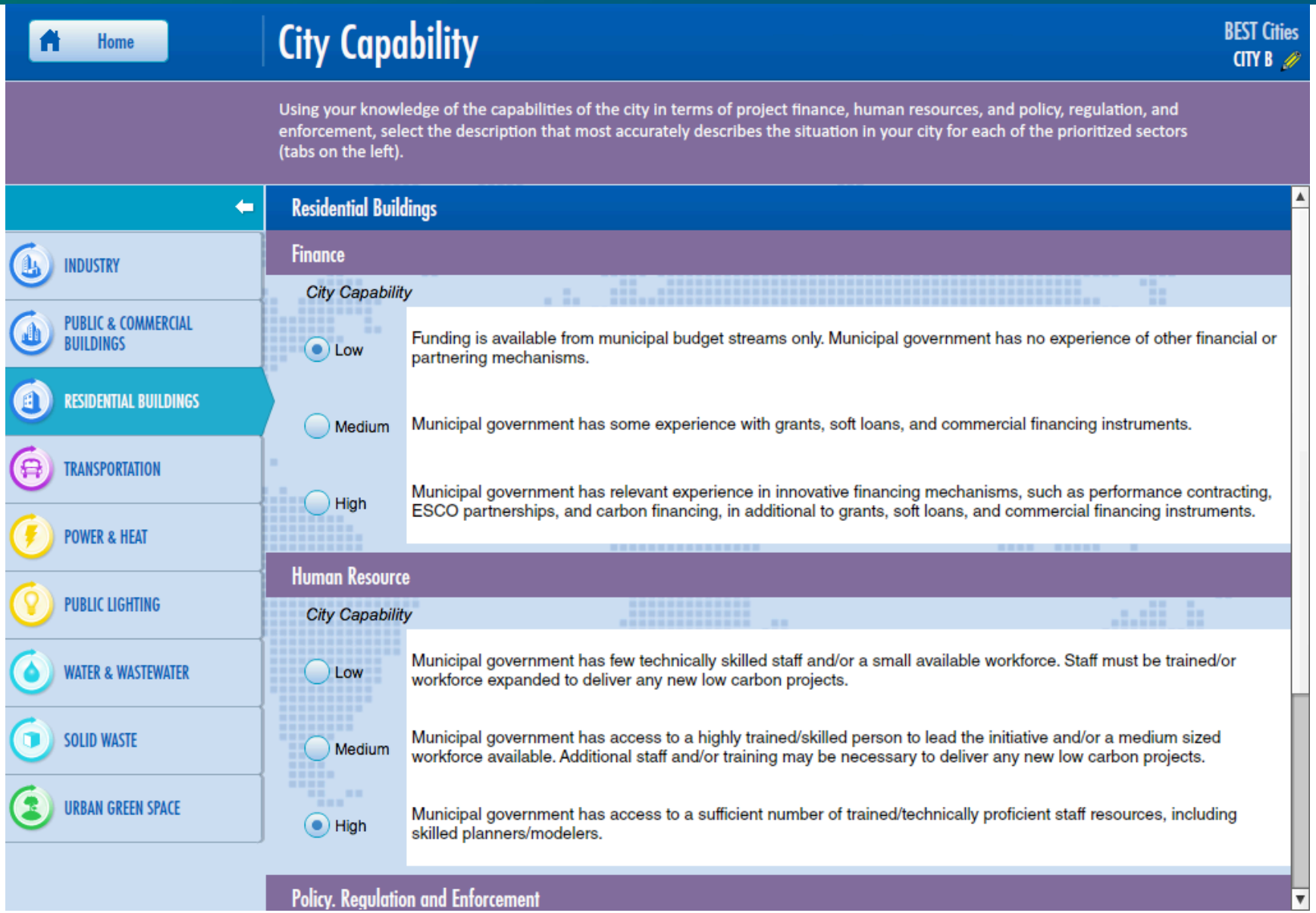
Rank	Sector	Sector Improvement Potential %	CO_2e Emissions (10^4 tCO_2e)	City Authority %	Score	Check priority sectors
1	Industry	15%	6,859.63	35%	360.13	✓
2	Public & Commercial Buildings	20%	3,345.18	50%	334.51	✓
3	Power & Heat	37%	3,548.39	20%	266.12	✓
4	Residential Buildings	10%	2,194.77	75%	164.60	✓
5	Solid Waste	87%	110.34	65%	62.66	✓
6	Transportation	10%	196.22	35%	6.86	✓
7	Urban Green Space	50%	-10.00	90%	4.50	✓
8	Water & Wastewater	10%	5.03	20%	0.10	✓
9	Public Lighting	9%	0.04	75%	0.00	✓

Benchmarking and Energy Saving Tool for Low Carbon Cities (BEST-Cities)

Policy Analysis

- Identifies energy-saving and emissions-reduction policies and programs
- Database of more than 70 policies and programs that can be adopted at the city level
  - Policy/program description
  - Implementation strategies and challenges
  - Monitoring metrics
  - Case studies
  - Attributes: carbon saving potential, first cost to government, speed of implementation, co-benefits

City Capability



Buildings Policies

Residential Buildings	Public and Commercial Buildings
Reach Standards for Efficient Appliance and Equipment	More Stringent Local Building Codes
Building Workforce Training	Green Building Guidelines for New Buildings
Green Building Guidelines for New Buildings	Expedited Permitting for Green Buildings
More Stringent Local Building Codes	Targets for Efficient and Renewables in Buildings
City Energy and Heat Maps	Building Energy Labeling and Information Disclosure
Building Energy Labeling and Information Disclosure	Mandatory Building Energy-Efficiency Audit
Targets for Efficient and Renewables in Buildings	Public Education Campaigns on Building Energy Efficiency and Conservation
Expedited Permitting for Green Buildings	Municipal Building Energy Efficiency Task Force
Retrofit Subsidies and Tax Credits for Existing Buildings	Energy Performance Contracting and Energy Service Companies
Subsides for New Buildings that Exceed Building Code	Retrofit Subsidies and Tax Credits for Existing Buildings
Energy-Efficient Equipment and Renewable Energy Technology Purchase Subsidies	Subsides for New Buildings that Exceed Building Code
Public Education Campaigns on Building Energy Efficiency and Conservation	City Energy and Heat Maps
	Cooperative Procurement of Green Products
	Financial Incentives for Distributed Generation in Buildings

Policy Review

Home

Policy Review

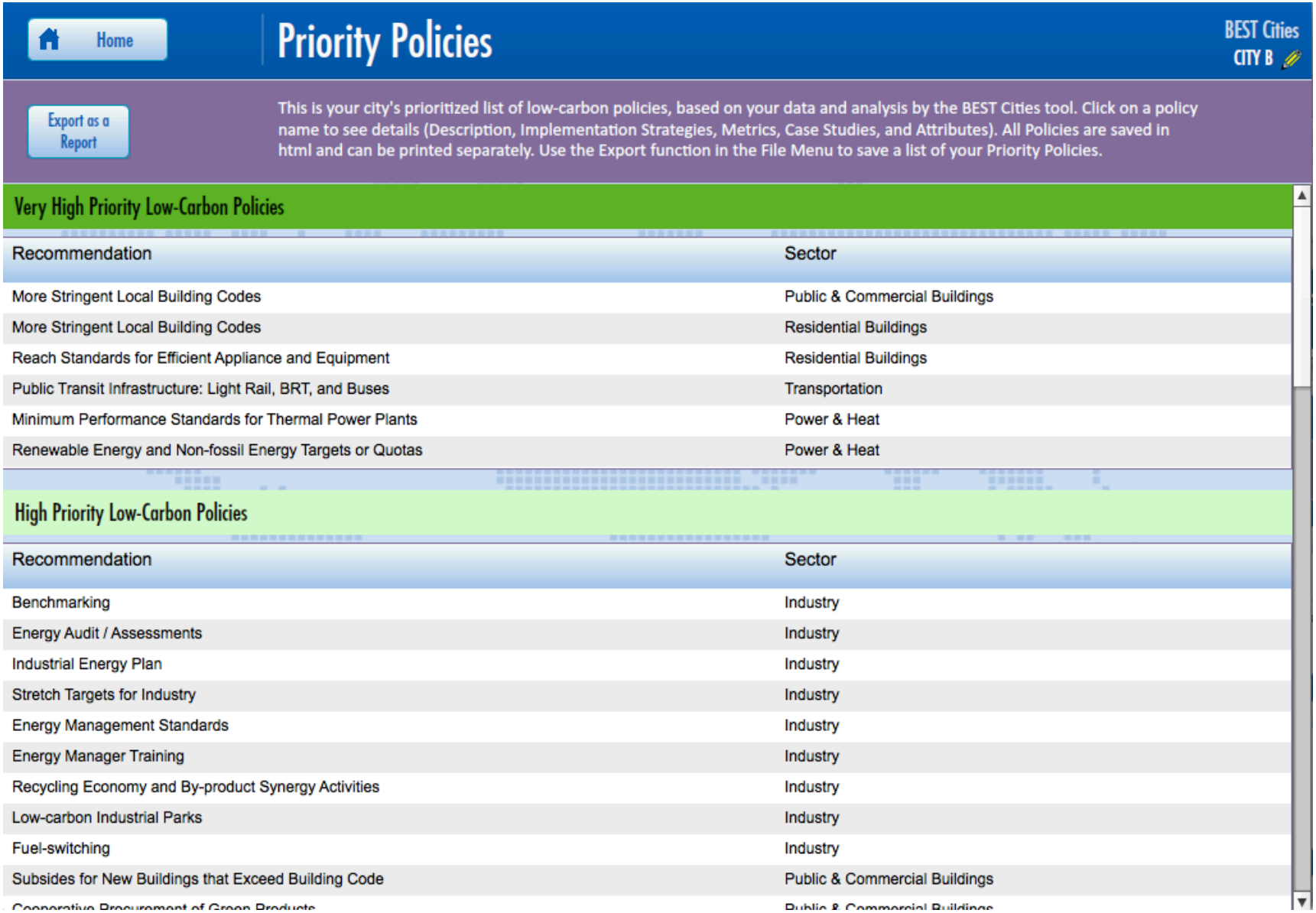
BEST Cities
CITY B

Export as a Report

All policies selected through Policy Appraisal are displayed below, 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.

		For a city of 5 million - 9,999,999 population:			
Sector	Policy	Speed of Implementation	Carbon Savings Potential (tCO_2e)	First Cost to Government (RMB)	Override
Residential Buildings	Green Building Guidelines for New Buildings	< 1 Year	500,000 - 2.5 million	< 5 million	Override
Residential Buildings	City Energy and Heat Maps	< 1 Year	< 500,000	< 5 million	Override
Residential Buildings	Building Energy Labeling and Information Disclosure	1-3 Years	500,000 - 2.5 million	< 5 million	Override
Residential Buildings	Building Workforce Training	< 1 Year	< 500,000	< 5 million	Override
Residential Buildings	More Stringent Local Building Codes	> 3 Years	> 2.5 million	5 million - 50 million	Override
Residential Buildings	Reach Standards for Efficient Appliance and Equipment	1-3 Years	> 2.5 million	< 5 million	Override
Residential Buildings	Targets for Efficient and Renewables in Buildings	1-3 Years	500,000 - 2.5 million	< 5 million	Override
Residential Buildings	Expedited Permitting for Green Buildings	< 1 Year	< 500,000	< 5 million	Override
Residential Buildings	Retrofit Subsidies and Tax Credits for Existing Buildings	1-3 Years	500,000 - 2.5 million	> 50 million	Override
Residential Buildings	Subsides for New Buildings that Exceed Building Code	1-3 Years	500,000 - 2.5 million	5 million - 50 million	Override
Residential Buildings	Energy-Efficient Equipment and Renewable Energy Technol	1-3 Years	> 2.5 million	> 50 million	Override
Residential Buildings	Public Education Campaigns on Building Energy Efficiency a	< 1 Year	< 500,000	< 5 million	Override

Priority Policies



Very High Priority Low-Carbon Policies

Recommendation	Sector
More Stringent Local Building Codes	Public & Commercial Buildings
More Stringent Local Building Codes	Residential Buildings
Reach Standards for Efficient Appliance and Equipment	Residential Buildings
Public Transit Infrastructure: Light Rail, BRT, and Buses	Transportation
Minimum Performance Standards for Thermal Power Plants	Power & Heat
Renewable Energy and Non-fossil Energy Targets or Quotas	Power & Heat

High Priority Low-Carbon Policies

Recommendation	Sector
Benchmarking	Industry
Energy Audit / Assessments	Industry
Industrial Energy Plan	Industry
Stretch Targets for Industry	Industry
Energy Management Standards	Industry
Energy Manager Training	Industry
Recycling Economy and By-product Synergy Activities	Industry
Low-carbon Industrial Parks	Industry
Fuel-switching	Industry
Subsides for New Buildings that Exceed Building Code	Public & Commercial Buildings
Cooperative Procurement of Green Products	Public & Commercial Buildings

Testing, Training, Dissemination

- Testing
  - Beta-testing of tool – Jinan, capital city of Shandong Province
- Training
  - Technology Development Strategy Institute of Shandong Academy of Science
- Dissemination
  - National Development and Reform Commission, Macroeconomic Institute, Energy Research Institute, National Center for Climate Change Strategy and International Cooperation, Energy Foundation China
  - U.S.-China EcoPartnerships: LBNL's China Energy Group and Shandong Academy of Science

Contact Information

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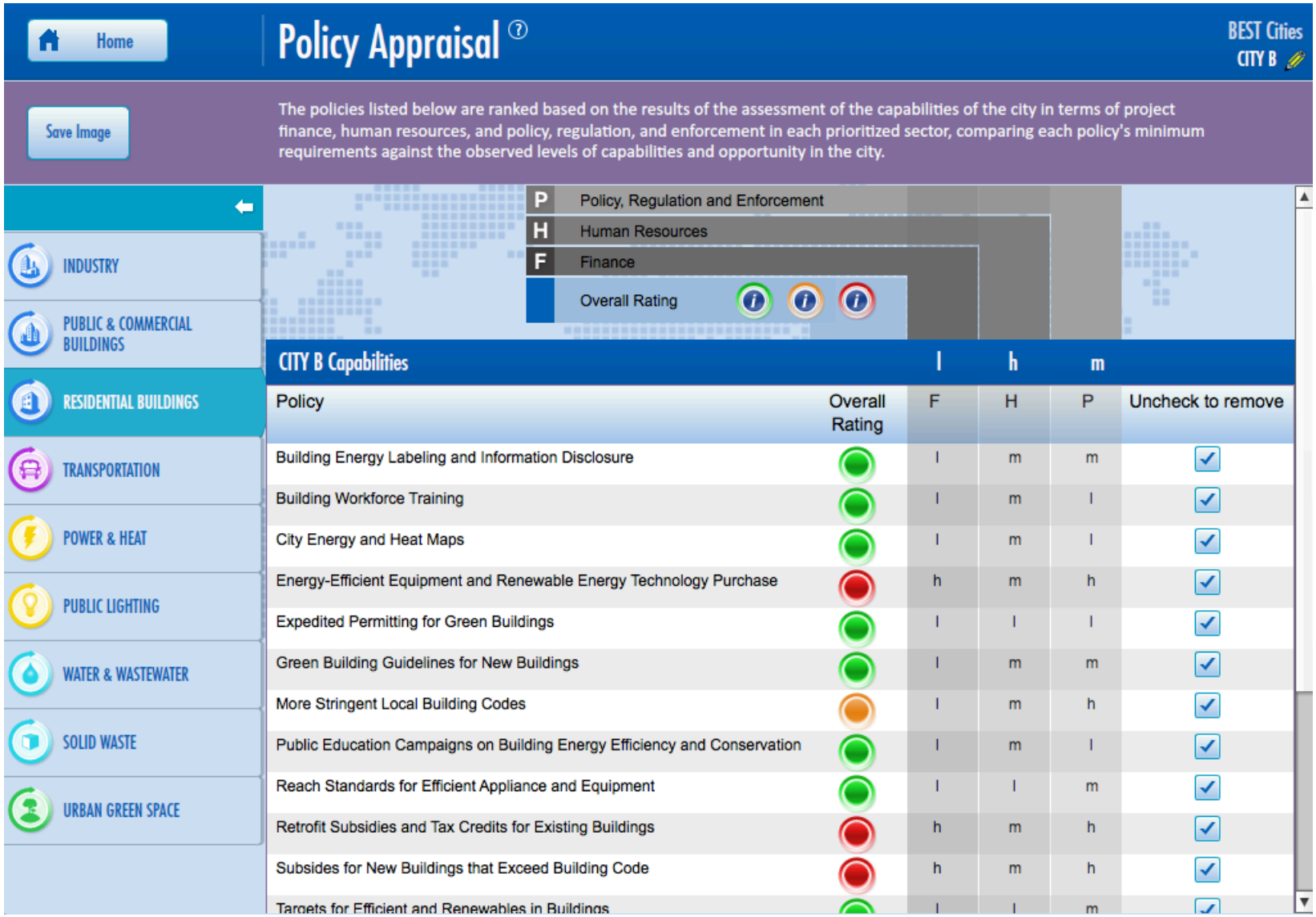
Policy Appraisal



Definition of Attribute Tags

- **Speed of Implementation: low (<1 year), medium (1-3 years), high (>3 years)**

- **Carbon Savings Potential: low, medium, high**

Speed of Implementation	Carbon Savings Potential (unit: tCO2e)					
	Varies by city size (unit: population)					
	<500K	500K – 1 m	1 -5 m	5 – 10 m	>10 m	
Low	< 1 year	< 50 K tCO2e	<125 K tCO2e	< 250K tCO2e	< 500K CO2e	<1 Mt CO2e
Med	1 – 3 years	50K -250 K tCO2e	1.25 -12.5 m tCO2e	2.5 -25 m tCO2e	500K – 2.5 m	1- 5 m tCO2e
High	>3 years	>250K tCO2e	> 625K tCO2e	>1.25 M tCO2e	>2.5 M tCO2e	>5 mtCO2e

- **First Costs: low, medium, high**

	First Cost (unit: RMB)				
	City Size (unit: population)				
	<500K	500K – 1 m	1 -5 m	5 – 10 m	>10 m
Low	500k RMB	<1.25 m RMB	<2.5 m RMB	<5 m RMB	<10m RMB
Med	500K - 5 m RMB	1.25 -12.5 m RMB	2.5 -25 m RMB	5 – 50 m RMB	10 – 100m RMB
High	>5 m RMB	>12.5 m RMB	>25 m RMB	>50 m RMB	>100 m RMB

Final Priority Definition

- Recommended policies in four "priority" categories:
  - Very high priority
  - High priority
  - Medium priority
  - Low priority

Carbon Savings Potential (tonne)

	>$1 million	$100,000 - $1 million	<$100,000
>200,000	*high*	*very high*	*very high*
100,000 - 200,000	*med*	*high*	*high*
<100,000	*low*	*med*	*med*

First Costs (dollar)

Recommendation Matrix