



ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

Low-Carbon City Policy Databook

**72 Policy Recommendations for Chinese Cities
from the Benchmarking and Energy Savings Tool for Low
Carbon Cities**

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Introduction

This report is designed to help city authorities evaluate and prioritize more than 70 different policy strategies that can reduce their city's energy use and carbon-based greenhouse gas emissions of carbon dioxide (CO₂) and methane (CH₄). Local government officials, researchers, and planners can utilize the report to identify policies most relevant to local circumstances and to develop a low carbon city action plan that can be implemented in phases, over a multi-year timeframe.

The policies cover nine city sectors: industry, public and commercial buildings, residential buildings, transportation, power and heat, street lighting, water & wastewater, solid waste, and urban green space. See Table 1 for a listing of the policies. Recognizing the prominence of urban industry in the energy and carbon inventories of Chinese cities, this report includes low carbon city policies for the industrial sector. The policies gathered here have proven effective in multiple locations around the world and have the potential to achieve future energy and carbon savings in Chinese cities.

Policy Analysis and Prioritization

The information in this report can help city authorities prioritize action across city sectors and evaluate the appropriateness of more than 70 policy strategies that save energy and carbon. By identifying the strategies most relevant to local circumstances, local researchers and government officials can develop a low carbon city action plan to be implemented in phases, over a multi-year timeframe.¹

This report provides a two-to-four page explanation and characterization of each policy, which includes:

- Policy Description
- Implementation Strategies and Challenges
- Monitoring Metrics
- Case Studies
- Policy Attributes:
 - Carbon Savings Potential
 - First Cost to Government
 - Speed of Implementation
- Tools and Guidance
- References

¹ The policies in this report are incorporated in the Benchmarking and Energy Saving Tool for Low-Carbon Cities (BEST Cities) software tool. For further information on BEST Cities, see: <https://china.lbl.gov/tools/benchmarking->

Table 1. Low-Carbon City 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
	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
	Subsidies for New Buildings that Exceed Building Code		Methane Capture and Reuse/ Conversion

Residential Buildings	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
	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
	Subsidies 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	Urban Green Space
			Urban Forestry Management

The Implementation Strategies and Challenges noted for each policy synthesize the experience with carrying out the policy in locations around the world. The Monitoring Metrics included with each policy aid in quantifying and tracking policy progress over time. The Case Studies illustrate application of the policies, providing specific, quantitative examples. The Tools and Guidance section provides further guidance and reference.

Policy Attributes

Each policy is characterized in terms of three Policy Attributes: Speed of Implementation, Carbon Savings Potential, and First Cost to Government. By considering Speed of Implementation, a city can choose a mix of quick achievements as well as activities that yield results over a longer time-frame. With the Carbon Savings Potential, cities can quickly gain a rough estimate of how policies can contribute to

their quantitative targets for carbon savings. Information on the First Cost to Government offers local government a swift but rough estimate of funding needed to launch a policy or program. The report provides a qualitative value of High, Medium, or Low for each attribute. The estimated ranges of quantitative values for these policy attributes are based on available case study data and vary with the size of the city; see Appendix 2 for the values.

City Capabilities

Each policy is also characterized in terms of the city government capabilities needed: (1) Finance, (2) Human Resources, and (3) Policy Enforcement. City officials can characterize their city capabilities as High, Medium, or Low for each area, for each sector. For example, in the Residential Buildings sector, city officials might have a Medium level of financing for residential building programs; High human resources, in terms of skilled staff; and Medium enforcement capabilities with numerous construction companies. Table 2 provides definitions for the three areas of City Capability.

Table 2. Definitions of City Capabilities

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 addition 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.

A city may choose not to undertake a policy with a poor match of capabilities. Or a city may choose an otherwise-promising policy and pursue enhancement of city capabilities for policy implementation.

City officials or researchers can match their own City Capabilities in each sector with the capabilities needed for each of the 72 policies in this report, utilizing Appendix 1, to identify feasible low carbon actions for the city to implement.

City Authority

When utilizing this report, keep in mind that the extent of local government city decision-making authority varies across city sectors. As a result, the role of local government varies for each of the policies analyzed in this report. For some policies, such as land-use decisions affecting urban green space or neighborhood building and street development, local government has substantial authority. For other policies, such as product efficiency standards established at the national level, local government's role is to actively implement or augment the policies, such as developing local purchasing policies to encourage the uptake of energy-efficient products. Local governments may also intensify national requirements, making more stringent standards at the local level, as with tougher building efficiency codes. Local government can also provide additional incentives or support to encourage widespread policy adoption, such as providing additional monetary incentives or technical workshops and training. Table 3 provides definitions and percent control ranges for City Authority.

Table 3: Definitions of City Authority

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.

From our work with Chinese cities, we find that local government typically has limited decision-making authority in the Power and Heat sector (<10%), meaning that Chinese cities haven't had the authority to establish their own electric power utilities or enter into power purchase agreements with renewably-powered generators. Local governments in China have somewhat more authority in Transportation decisions (10 – 40%); moderate to strong authority for Buildings, Industry, Water, and Waste (40% - 75%); and the greatest authority over decisions regarding Urban Green Space and Public Lighting (>75%). Pilot low-carbon cities, however, are testing new approaches that give cities greater authority to pursue energy and carbon savings, especially in the largest sectors of Power and Heat, as well as Industry. These pilot efforts can help to influence provincial and national policy, as well as city efforts across China.

Building Policy Recommendations

- B01: Energy-Efficient Equipment and Renewable Energy Technology Purchase Subsidies
- B02: Subsidies for New Buildings that Exceed Building Code
- B03: Retrofit Subsidies and Tax Credits for Existing Buildings
- B04: Cooperative Procurement of Green Products
- B05: Energy Performance Contracting and Energy Service Companies
- B06: Municipal Building Energy Efficiency Task Force
- B07: Expedited Permitting for Green Buildings
- B08: Targets for Efficient and Renewables in Buildings
- B09: More Stringent Local Building Codes
- B10: Green Building Guidelines for New Buildings
- B11: Financial Incentives for Distributed Generation in Buildings
- B12: City Energy and Heat Maps
- B13: Building Energy Labeling and Information Disclosure
- B14: Mandatory Building Energy-Efficiency Audit and Retrofits
- B15: Reach Standards for Efficient Appliances and Equipment
- B16: Building Workforce Training
- B17: Public education campaigns on building energy efficiency and conservation

B01: Energy-Efficient Equipment and Renewable Energy Technology Purchase Subsidies

Description

Various countries offer financial subsidies and rebates to promote energy-efficient building technologies by reducing the purchase cost to consumers or increasing the price received by manufacturers. For example, the UK offers capital subsidies for investment in qualifying energy-efficient equipment, and the U.S. offers federal, state, and local rebates for appliances that have the U.S. Department of Energy (U.S. DOE) ENERGY STAR label. Cities can complement provincial or national programs by adding a local subsidy or rebate, by facilitating an exchange program for appliances (de la Rue du Can et al. 2014), or by requiring that local government choose energy-efficient and renewable energy technology when making purchases.

In China, the National Development and Reform Commission “Benefits to the People” program offers subsidies to promote 10 categories of energy-efficient products as defined by the China Energy Label efficiency rating, including air conditioners and TVs. For example, subsidies of 300-650 renminbi (RMB)/unit are offered for air conditioners that have China Energy Label grade two, and 500-850 RMB/unit for those with China Energy Label grade one, which is the highest rating. Larger rebates are offered to rural residents. By the end of 2011, 218 million units had been sold through this program, with a total of 59.22 billion RMB in subsidies (China National Institute of Standardization, 2012).

China has also offered subsidies for renewable technologies in buildings at the local level, for example, subsidies of 800-900 RMB/kilowatt for renewable energy applications in buildings in Chongqing and 20 RMB/peak watt of solar photovoltaic demonstration projects (Levine et al., 2010). A performance metric for technology-based financial subsidies would increase investment and ultimately the market share of the efficient or renewable energy technologies targeted by subsidies or rebates.

Implementation Strategies and Challenges

Implementation Activity	Description
Identify target product for subsidy	Entity offering subsidy defines qualifying product types and criteria for subsidy.
Determine appropriate subsidy or rebate level	Entity offering subsidy determines amount of subsidy or rebate based on analysis to identify minimum amount needed to incentivize investment and spur market transformation.
Develop channels for subsidy or rebate transfer (e.g., retail)	Entity offering subsidy works with relevant stakeholders to develop channels for applying for and receiving subsidy/rebate (e.g., offer subsidy at point of sale or through rebate after purchase).
Promote and market subsidy or rebate to	Entity offering subsidy launches information campaigns

the public	and related media outreach to inform public about availability of subsidy/rebate.
Utilize an exchange program	Facilitate the exchange of an old inefficient appliance for part of the purchase cost of a new efficient appliance, to avoid increasing overall energy demand.
Disburse subsidy/rebate	Entity offering subsidy disburses subsidy/rebate to applicants.

Possible implementation challenges include: rebates might be insufficient to motivate customers to purchase energy-efficient and renewable energy products; it can be difficult to promote public awareness of the program; there can be challenges with program administration (e.g., rebate processing delays); actual performance of energy-efficient and renewable energy products might be lower than designed.

Monitoring Metrics

Some suggested metrics for this recommendation are:

- Number of products sold
- Share of products sold in the total market
- Total amount of subsidies
- Number of products in stock
- Market share of energy-efficiency or renewable energy products
- Estimated energy savings per product
- Cost-benefit ratio of product

Case Studies

Cash for Appliances Rebate Program, USA

<http://energy.gov/articles/secretary-chu-announces-nearly-300-million-rebate-program-encourage-purchases-energy>

In 2009, U.S. DOE initiated a federal “cash for appliances” program that provided rebates to consumers who purchased a wide array of ENERGY-STAR-certified efficient home appliances. The goal of the program was to improve energy efficiency and assist the nation’s economic recovery. Total funding for this program was nearly US\$300 million (2049 million RMB).² Federal funding for the program was awarded to states and regions through energy offices, using a formula specified in the Energy Policy Act

² World Bank official 2009 exchange rate: 1 USD = 6.83 RMB.
<http://data.worldbank.org/indicator/PA.NUS.FCRF>

of 2005. Each state or region submitted a plan that specified which ENERGY STAR appliance categories to include in the rebate program, the rebate level for each product type, how the rebates are processed, and the plan for recycling old appliances. U.S. DOE recommended that states consider the following ENERGY STAR-qualified appliances: boilers, central air conditioners, clothes washers, dishwashers, freezers, furnaces (oil and gas), heat pumps (air source and geothermal), refrigerators, room air conditioners, and water heaters. Two states that implemented the program early were Illinois, which received US\$12.4 million (84.7 million RMB), and Iowa, which received US\$2.8 million (19.1 million RMB).

PG&E Residential Energy Efficiency Rebates Program, California, USA

http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA57F

Pacific Gas and Electric Company (PG&E), a large investor-owned utility in Northern California, offers a residential appliance rebate program as part of its portfolio of energy-efficiency programs. PG&E's residential rebate list for the year 2013-2014 includes: US\$50/unit (316 RMB/unit)³ for qualifying high-energy and water-efficient clothes washers, US\$75/unit (473 RMB/unit) for qualifying high-efficiency refrigerators, US\$200/unit (1,262 RMB/unit) for ENERGY STAR high-efficiency gas storage water heaters, and US\$500/unit (3,155 RMB/unit) for ENERGY STAR electric heat pump water heaters. PG&E customers who purchase and install qualifying high-efficiency appliances can apply for the rebate at the retailer or by submitting an on-line or mail-in application after purchase.

Attributes

- Carbon Savings Potential
High
- First Cost to Government
High
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced carbon emissions, increased thermal comfort of homes, increased employment opportunities, financial savings for low-income families

³ World Bank's official 2012 exchange rate: 1 USD = 6.31 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

Tools and Guidance

Camco Advisory China and the Energy Research Institute of China. 2009. *Using financial and market-based mechanisms to improve building energy efficiency in China*. March, 2009. Available at: http://www.reeep.org/file_upload/5272_tmpphp625jEK.pdf.

United Nations Development Programme (UNDP). 2009. *Promoting energy efficiency in buildings: lessons learn from international experience*. March, 2009. Available at: http://www.thegef.org/gef/sites/thegef.org/files/publication/EEBuilding_WEB.pdf.

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de la Rue du Can, S., G. Leventis, A. Phadke, A. Gopal. 2014. "Design of Incentive Programs for Accelerating Penetration of Energy-Efficient Appliances." *Energy Policy*, v. 72, September, pp. 56–66.

Levine, M.D., L. Price, N. Zhou, D. Fridley, N. Aden, H. Lu, M. McNeil, N. Zheng, Y. Qin and P. Yowargana. 2010. *Assessment of China's Energy-Saving and Emission Reduction Accomplishment and Opportunities during the 11th Five Year Plan*. LBNL-3385E. Berkeley, CA: Lawrence Berkeley National Laboratory.

B02: Subsidies for New Buildings that Exceed Building Code

Description

Financial subsidies have been used internationally to encourage building developers and owners to adopt energy-efficient designs, technologies, and techniques; use energy-efficient equipment, appliances, materials, and products; and implement energy-saving operations and management practices throughout a building's design, construction, and operational phases. A number of subsidies target new construction projects that exceed the efficiency requirements in existing building energy codes. These subsidies are typically funded by government, utility public benefit, and green revolving loan programs. Although most of the subsidy programs have been provided at the national or regional level, cities can also introduce complementary or new subsidy programs for building projects within its jurisdiction.

Implementation Strategies and Challenges

Implementation Activity	Description
Determine appropriate subsidy level	Entity offering subsidy determines different amounts of subsidy related to different levels of energy efficiency in new buildings that exceed existing building energy codes.
Determine financial resources	Entity offering subsidy determines financial resources, such as funding from government, utility public benefit funds, and green revolving loan programs
Develop channels and procedures for subsidy	Entity offering subsidy works with relevant stakeholders to develop channels and procedures for applying for and receiving subsidy.
Promote and market subsidy to the public	Entity offering subsidy launches information campaigns and related media outreach to inform public about availability of subsidy, and enterprises/customers that have been subsidized.

Some possible implementation challenges include: high first costs of energy-efficient or green building applications and technologies compared to the size of subsidies; lack of understanding of a building's life-cycle costs; lack of skilled service providers, materials vendors, and integrated design teams for constructing energy-efficient and green buildings; lack of coordination and consistency in government policies affecting buildings; and lack of awareness of subsidy programs.

Monitoring Metrics

Some suggested measures for this policy are as follows:

- Number of projects completed per year
- Number of projects currently being carried out
- Total amount of subsidies per year
- Kilowatt hour of annual electrical energy intensity per square meter (kWh_e/m^2), by type of building (school, office, residential, hospital, etc.)
- Kilowatt hour annual heating energy intensity per square meter (kWh_h/m^2), by type of building
- Renminbi per square meter (RMB/m^2) investment cost, by type of building

Case Studies

Saving By Design (SBD), California, USA

<http://www.savingsbydesign.com/>

The Saving By Design program uses incentives and design assistance and resources to encourage high-performance and highly energy-efficient new non-residential construction. The program is administered by state utilities and funded by utility customers through a Public Purpose Programs surcharge applied to gas and electric services. This program provides financial incentives to pay for energy savings that exceed the state's Title 24 building energy code by at least 10%, using the whole buildings or systems approach. Projects participating in Saving By Design are also eligible to receive services including design assistance and energy design resources in addition to financial incentives for building owners and building design teams. Services begin during the project design phase and continue until completion of construction.

Efficiency Vermont, Vermont, USA

http://www.efficiencyvermont.com/for_my_home/ways-to-save-and-rebates/building_buying_new_home/building_buying_new_home/general_info/overview.aspx

Efficiency Vermont offers two different programs that provide technical assistance, rebates, and other financial incentives for new homes designed and built to exceed the state's Residential Building Standard. The Vermont ENERGY STAR Homes program provides design assistance, guidance for purchase and installation of efficient equipment, home inspection and Home Energy Rating certification, and financial rebates for residential builders (i.e., developers or private homeowners) of an ENERGY STAR-qualified home. For example, qualifying homes can receive US\$200 (1,262 RMB)⁴ for installing at least two high-efficiency appliances and US\$75 (473 RMB) per point below 60 points in the Home Energy Rating index. The Energy Code Plus program provides similar technical assistance and services to help builders meet and exceed the state's building code but differs in that the homes do not have to meet

⁴ According to the World Bank official 2012 exchange rate, 1 USD = 6.31 RMB.
<http://data.worldbank.org/indicator/PA.NUS.FCRF>

the more efficient ENERGY STAR qualifications. The program is open to builders/general contractors hired by homeowners as well as homeowners who choose to be their own contractors.

Incentives for Green Building Implementation, China

http://www.gov.cn/zwgk/2012-05/07/content_2131502.htm

China's Ministry of Housing and Urban-Rural Development and the Ministry of Finance jointly announced in April 2012 a financial incentive program to promote China's green building rating system. This program awards financial incentives to green buildings that achieve high ratings under the national green building rating system. Specifically, the incentive for two-star green buildings is 45 RMB/m² and for three-star green buildings is 80 RMB/m². Applicants submit a design plan, Green Building Label rating and evaluation report, engineering construction approval documents, and a performance analysis to an expert committee for review. All successful applicants' files are put on record, and each completed project's performance is verified by an energy-efficiency testing agency. For large public buildings, verification is conducted after the building has been operating for one year. The list of eligible applicants is announced to the public, and, after verification, filing, and an announcement, eligible applicants receive their incentives.

Attributes

- Carbon Savings Potential
Medium
- First Cost to Government
Medium
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced carbon emissions, improved air quality, enhanced public health and safety, increased employment opportunities, financial savings

Tools and Guidance

U.S. Green Building Council. <https://new.usgbc.org>

World Green Building Council. <http://www.worldgbc.org/site2/>

Sustainable Building Tool Kit. California Department of Resources Recycling and Recovery.
<http://www.calrecycle.ca.gov/greenbuilding/toolkit.htm>

B03: Retrofit Subsidies and Tax Credits for Existing Buildings

Description

Similar to financial incentives for developers of new buildings, financial incentives for owners of existing buildings encourage investment in energy-efficient and low-carbon (e.g., renewable energy) retrofits. Many municipalities around the world already offer retrofit subsidies or tax credits to promote energy efficiency in existing buildings, particularly in regions such as the European Union where new construction is limited. These programs are funded through taxes, fees, or federal and state monies. Grant programs often require homeowners and commercial building owners to submit an application or proposal, undergo an energy audit, and meet other program requirements (e.g., income requirements for low-income retrofit subsidies). Tax credits reduce a homeowner or building owner's tax bill for buildings that achieve measurable, verifiable green building goals. Although retrofit grants and tax credits impose additional costs on local municipalities funding the programs, the increase in the assessed value of buildings that install green and energy-efficient features over time frequently offsets reductions in revenue resulting from tax credits.

Implementation Strategies and Challenges

Implementation Activity	Description
Determine appropriate subsidy/tax credit level	Entity offering subsidy/tax credit determines amount of subsidy/tax credit relate to energy efficient and low-carbon building technologies and potential energy savings. The criteria of subsidy/tax credit are determined based on analysis to identify minimum amount needed to incentivize investment and spur market transformation.
Determine financial resources	Entity offering subsidy/tax credits determines financial resources, such as funding from government, utility public benefit, and green revolving loan programs
Develop channels and procedures for subsidy/tax credits	Entity offering subsidy works with relevant stakeholders to develop channels and procedures for applying for and receiving subsidy/tax credits.
Promote and market subsidy/tax credits to the public	Entity offering subsidy/tax credits launches information campaigns and related media outreach to inform public about availability of subsidy, and enterprises/customers that have received subsidies/tax credits.

Possible challenges during the design and implementation of building retrofit subsidies and tax credits include: difficulty in determining appropriate incentive or tax credit level for retrofit uptake, low participation because of lack of awareness of available subsidies or tax credits or burden of applying for and receiving the subsidy/credit, insufficient contractors and retrofit professionals.

Monitoring Metrics

Some suggested measures for monitoring/oversight for this policy recommendation include:

- Number of retrofit projects completed per year
- Number of retrofit projects currently being carried out
- Total number of retrofit measures installed as a result of the program
- Annual subsidies or tax credits provided by the program
- Kilowatt hour of annual electrical energy intensity per square meter (kWh_e/m^2), by type of building (schools, offices, residential, hospitals, etc.)
- Kilowatt hour of annual heating energy intensity per square meter (kWh_h/m^2), by type of building
- Annual energy cost intensity per square meter (RMB/m^2), by type of building

Case Studies

Green Roof Incentive Program, Chicago, Illinois, USA

<http://www.sustainable-chicago.com/2008/04/23/green-building-and-climate-in-chicago/>

The City of Chicago initiated a Green Roof Improvement Fund in 2001 to provide a 50% grant match for the cost of placing a green roof on an existing building located in the Central Loop Tax Increment Financing District, with the aim of decreasing the urban heat island effect. The grant match program provides up to a maximum grant of US\$100,000 (828,000 RMB)⁵ per project. The financial assistance covers engineering and construction of the green roof. The city plans to increase the number of funded green roof projects from 400 in 2008 to 6,000 by 2020. In addition, Chicago has the Green Roof Grant Program, which awards US\$5,000 (41,400 RMB) grants for residential and small commercial green roof projects.

⁵ World Bank official 2011 exchange rate: 1 USD = 8.28 RMB.
<http://data.worldbank.org/indicator/PA.NUS.FCRF>

Commercial Building Energy Efficiency Retrofit Program, Charlotte, North Carolina, USA

<http://charmeck.org/city/charlotte/econrecovery/Pages/CommercialBuildingEnergyEfficiencyRetrofitProgram.aspx>

The City of Charlotte's Commercial Building Energy Efficiency Retrofit Program is designed to improve the energy efficiency of existing, for-profit commercial and multi-family buildings by partially reimbursing the cost of energy-efficiency improvements. This program is open to qualifying buildings located within the city's business corridor, which is targeted for revitalization. The program goal is to increase energy efficiency of existing structures by 15% or more. The subsidy focuses on lowering the energy consumption of existing buildings by reimbursing a percentage of retrofit measures including energy audits; energy-efficient lighting; heating, ventilation, and air conditioning (HVAC) equipment; and doors and windows. In 2012, the program leveraged more than US\$7.33 million (46 million RMB)⁶ and was on track to complete retrofits of more than 1,300 residential units and 540,000 sq. ft. (164,592 m²) of non-residential space.

Low-income Energy-Efficiency Grant Program, Tallahassee, Florida, USA

<http://energy.gov/savings/city-tallahassee-utilities-low-income-energy-efficiency-grant-programs>

The City of Tallahassee Utilities offers two grants that encourage low-income residents to improve home energy-efficiency. To be eligible for these programs, a homeowner must complete a mandatory free home energy audit and meet the qualifying income levels.

The Ceiling Insulation Grant is available to low-income utility customers in both owner-occupied and rental units. Grants of up to US\$500 (3,155 RMB)⁷ are available for extra ceiling insulation where the existing level is insufficient. The program's target insulation levels are R-38 for homes heated with gas and R-49 for homes with electric heat. The HVAC Repair Grant is available to low-income residents living in owner-occupied homes, including mobile homes. It provides up to US\$500 (3,155 RMB) to clean evaporator coils; repair refrigerant, hot water and duct leaks; and perform other HVAC efficiency improvements. The City of Tallahassee also offers the Code Enforcement Rehabilitation Grant (US\$2,500/15,775 RMB) to low-income customers. This program is not limited only to energy-efficiency improvements, but measures that improve residential energy efficiency, such as changing out inoperable heating systems and water heaters or replacing broken windows, could be funded by this grant.

Attributes

- Carbon Savings Potential

⁶ World Bank official 2012 exchange rate: 1 USD = 6.31 RMB.
<http://data.worldbank.org/indicator/PA.NUS.FCRF>

⁷ Based on the 2012 exchange rate: 1 USD = 6.31 RMB.

Medium

- First Cost to Government

High

- Speed of Implementation

1-3 years

- Co-Benefits

Reduced carbon emissions, improved air quality, increased employment opportunities, financial savings, improved thermal comfort, increased property value

Tools and Guidance

U.S. Environmental Protection Agency ENERGY STAR. Building upgrade manual. Available at:
http://www.energystar.gov/index.cfm?c=business.bus_upgrade_manual.

U.S. Department of Energy. Commercial reference buildings. Available at:
http://www1.eere.energy.gov/buildings/commercial/ref_buildings.html.

U.S. Department of Energy. EnergyPlus energy simulation software. Available at:
<http://apps1.eere.energy.gov/buildings/energyplus/>.

National Renewable Energy Laboratory. Energy modeling for retrofit projects. Available at:
http://openstudio.nrel.gov/files/openstudio_retrofit_tutorial.pdf.

B04: Cooperative Procurement of Green Products

Description

Cooperative procurement entails two or more organizations entering into a joint purchasing agreement to aggregate demand, which reduces the unit cost of products by maximizing economies of scale.

Cooperative procurement for environmentally preferred products and services, also known as environmentally preferable purchasing (EPP) or green purchasing, is the selection and acquisition of products and services that most effectively minimize negative environmental impacts over their life cycle of manufacturing, transportation, use, and recycling or disposal. Green purchasing includes: products and services that conserve energy and water, minimize generation of waste, and release of pollutants; products made from recycled materials and products that can be reused or recycled; energy from renewable resources; alternate fuel vehicles; and products using alternatives to hazardous or toxic chemicals, radioactive materials, and bio-hazardous agents.

Germany began structured green public procurement in the 1980s, followed by other European countries including Denmark (1994), France (1995), the UK and Austria (1997), and Sweden (1998). In 1999, the U.S. Environmental Protection Agency developed Guidance for Environmentally Preferable Purchasing, and in 2000 Japan enacted its Green Purchasing Law.

Implementation Activity	Description
Establish program	Entity implementing the program establishes cooperative procurement by formulating scope, policies, and requirements for potential participants.
Form cooperative	Cooperative is formed when one or more parties identify a common need suitable for cooperative purchase and sign a written agreement to cooperate.
Request bids	A request for bids (RFB) is used after the implementing entity develops clear specifications for the energy-efficient product to be procured.
Evaluate bids	An evaluation committee is established to select the product vendor. The award is usually made to the lowest bid that meets all RFB requirements.
Sign agreement	After selection of successful bidder, representative of implementing entity issues agreement delineating terms and conditions of the procurement contract.
Review and evaluate	Agency reviews and evaluates the process and actual energy savings.
Disclose information	Implementing entity makes all review and evaluation documents publicly available.

This policy recommendation aims to bridge the gap between EPP supply and demand. Cooperative procurement initiates a demand pull by means of consolidated purchasing power that motivates manufacturers to produce green products at a lower price and thus spurs market transformation. The

process is often as follows: a group of buyers are brought together by an independent organization such as an energy agency. The buyer group shares a common need for a product for which the group develops a performance-based technical specification. With the specification as the basis, the group issues a call for tenders, and manufacturers submit bids in response. Group participants could be corporations, national and local governmental organizations, non-governmental environmental organizations, and consumer groups.

Implementation Strategies and Challenges

Some possible challenges to implementing green purchasing practices include: lack of corporate commitment to green procurement; insufficient green purchasing knowledge and experience (such as unclear definitions and standards for “green” products); high costs of green products and services and lack of environmental awareness on the part of suppliers; logistical or coordination challenges; lack of awareness or commitment to green procurement among those responsible for procurement.

Monitoring Metrics

Some suggested monitoring and oversight measures for this policy recommendation include:

- Number of participants and their combined purchasing power
- Market share of products obtained through procurement
- Actual energy savings
- Reduced carbon dioxide (CO₂) emissions
- Other environmental benefits
- Financial savings

Case Studies

City of San Francisco Green Purchasing Program, USA

www.epa.gov/statelocalclimate/documents/pdf/energyefficientpurchasing.pdf

To reduce negative human and environmental health impacts of city purchases, the San Francisco Department of Environment established the city’s Green Purchasing Program in 2003. This program provides guidance on purchasing environmentally preferred products to the four divisions that purchase products for the city’s 30,000 employees and 90 departments and offices. The San Francisco Approved List is a publicly available list of more than 1,000 products that meet city environmental and health standards. The list encompasses more than least-toxic products and takes a life-cycle approach to assessing the city’s purchasing trends. It includes carbon footprint accounting, packaging reduction, and examination of labor practices for everything from food to vehicles to uniforms. The city uses its purchasing power to incentivize companies to reveal product ingredient data that are not usually readily available to consumers.

Since San Francisco began its Green Purchasing Program, it has introduced more than 1,000 zero- or low-emission vehicles to the city fleet and saved 6,800 trees and more than 500,000 gallons of water

each year by purchasing recycled content paper. The city has also cut municipal pesticide use by nearly two-thirds and dramatically increased the purchase of low-mercury, long-life fluorescent lamps.

A cost analysis of San Francisco's Green Purchasing efforts to date has concluded that purchase costs for green products are generally comparable to those of traditional products, with some green products costing less. If all city janitors use green products, the city saves an average of US\$63,745 (402,231 RMB)⁸ per year; savings are attributable to cheaper packaging and shipping, decreased product use, and avoided injuries. Adoption of green purchasing by the city's fleet and building maintenance employees saves approximately US\$32,110 (201,636 RMB) per year. Although environmentally preferable lamps (compact fluorescents) cost 10 times more than conventional lamps, the energy saved pays back the additional cost in 2-4 months. Replacing incandescent exit signs with light-emitting diode (LED) signs reduces replacement frequency from once every four months to once every 10 years, saving about US\$15 per sign/year (94.65 RMB/sign/year) in labor and \$12/year (75.72 RMB/year) in energy. The total city staff time allocated to green purchasing activities amounts to approximately 2.5 staff positions (Geiger, 2012).

The city identifies the following steps as crucial for successful implementation of the Green Purchasing program: securing funds for a full-time Green Purchasing Coordinator, enlarging the role of city vendors, and replacing the city's purchasing software.

Green Purchasing Network, Japan

<http://www.gpn.jp/English/index.html>

The Green Purchasing Network (GPN) was established in 1996 by 84 organizations responding to a request from the Ministry of the Environment (MoE) for EPP participants. GPN was at that time considered a nationwide organization for consolidated purchasing power. Today, it is a multi-stakeholder network with more than 2,900 member organizations, including 2,300 corporations, 300 national and local governmental organizations, and 280 non-governmental environmental organizations and consumer groups committed to promoting green procurement. The Japan Environment Association serves as the secretariat of the GPN. The GPN has drawn up principles of green procurement and procurement guidelines for each type of product (16 product categories and more than 11,000 products as of January 2007), which are developed through discussions among the members and external consultants. Since 1997, GPN has published quantitative and qualitative environmental information on various products, held seminars and conferences, and given awards to organizations that have demonstrated remarkable performance in implementing green purchasing. The systematic green purchasing aims for all local governments, 50% of public listed companies, and 90% of the public to be aware of green purchasing and 50% to implement green purchasing by 2015.

According to a survey conducted by MoE in 2005, all central governmental agencies had already implemented green procurement. Their annual performance is disclosed on each agency's website. All

⁸ World Bank official 2012 exchange rate: 1 USD = 6.31 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

47 prefecture governments had developed procurement policies as of 2005. A growing number of businesses have also already established green purchasing policies or are in the process of developing policies. The 32 items in 10 categories that qualify for green procurement have increased their market share. The domestic market for green products has been estimated at 50 trillion yen (3,220 billion RMB)⁹ (Sato, 2007). In 2010, based on estimated lifetime period (5 years for copiers, 10 years for household appliances, and 7 years for vehicles) of product use, total reduction of 124,435 tCO₂ emissions was achieved, the equivalent of residential CO₂ emitted by about 61,000 people (Kataoka, 2012).

Attributes

- Carbon Savings Potential
Medium
- First Cost to Government
Low
- Speed of Implementation
< 1 year
- Co-Benefits
Reduced carbon emissions, increased employment opportunities, enhanced public health and safety, financial savings

Tools and Guidance

National Association of State Procurement Officials (NASPO). Strength in numbers: an introduction to cooperative procurements. Available at:

http://www.naspo.org/documents/Cooperative_Purchasing0410update.pdf.

References

Geiger, C., 2012. Environmental health best practice: environmental precautionary purchasing. Accessed November 19, 2012. http://greencitiescalifornia.org/best-practices/envirom-health/SF_envirom-precautionary-purchasing.html.

Kataoka, A., 2012. Green purchasing trends in Japan and international network. September 2012. http://greenliving.epa.gov.tw/GreenLife/green-life/file/277/%E5%85%AC%E5%85%B1%E7%B6%A0%E8%89%B2%E6%8E%A1%E8%B3%BC%E5%92%8C%E7%B6%A0%E8%89%B2%E6%8E%A1%E8%B3%BC%E5%9C%A8%E6%97%A5%E6%9C%AC%E5%92%8C%E5%9C%8B%E9%9A%9B%E4%B9%8B%E8%B6%A8%E5%8B%A2Akira_Kataoka.pdf.

Sato, H., 2007. Green supply chain and green purchasing. January 2007, India.

⁹ Based on the 2007 average exchange rate: 1 YEN = 0.0644 RMB.
<http://www.oanda.com/currency/historical-rates/>

B05: Energy Performance Contracting and Energy Service Companies

Description

Energy Performance Contracting (EPC) is a turnkey service used in the building and other end-use sectors. EPC has been used in building design and construction contracting, e.g., in U.S. commercial building retrofits. EPC provides customers—which have included municipal governments—with a comprehensive set of energy-efficiency, renewable energy, and distributed generation measures that is often accompanied by guarantees that the financial savings from the project’s conserved energy will be sufficient to finance the project’s full cost. Energy Service Companies (ESCOs) play an important role in EPC; the different roles of ESCOs can be described as follows (U.S. EPA, 2007):

- **Turnkey Service:** the ESCO provides all of the services required to design and implement a comprehensive project for the client’s facility, from the initial energy audit through long-term monitoring and verification of project savings.
- **Comprehensive Measures:** the ESCO tailors a comprehensive set of measures to fit the needs of a particular facility, including energy efficiency, renewables, distributed generation, water conservation, and sustainable materials and operations.
- **Project financing:** the ESCO arranges for long-term project financing from a third party, typically in the form of an operating or municipal lease.
- **Project Savings Guarantee:** the ESCO provides a guarantee that the savings produced by the project will be sufficient to cover the cost of project financing for the life of the project.

The U.S. ESCO market is considered mature with US\$2 billion (16.56 billion RMB)¹⁰ revenue in 2002. ESCOs are also active in Europe, Japan, India, and Mexico (IPCC 2007). In China, ESCOs have primarily been used to improve the energy efficiency of industrial facilities and promoted by former Premier Wen Jiabao at a March 17, 2010 State Council executive meeting discussing policies and measures to accelerate the development of ESCOs and energy management contracting (China Climate Change Info-Net 2010). This meeting emphasized that China would actively promote mechanisms that facilitate energy management contracting and ESCO services in design, retrofit, and operations management for companies, public institutions, and others.

Implementation Strategies & Challenges

Implementation Activity	Methodology
Set goal	The client (e.g., a city government) sets an energy reduction goal for its building(s).
Issue request for proposal,	The client issues a request for proposals (RFP) for the desired retrofit project. ESCOs can respond to the RFP, identifying the proposed cost-effective energy-efficiency and conservation measures for achieving the client’s goal.

¹⁰ According to the World Bank official 2002 exchange rate: 1 USD = 8.28 RMB.
<http://data.worldbank.org/indicator/PA.NUS.FCRF>

Select contractors	The client evaluates the submitted bids and reviews the qualifications as a basis for choosing a service provider.
Sign contract	Once a service provider has been selected, a contract is agreed upon between the client and the selected ESCO or ESCOs, delineating the proposed project details, estimated costs, and other terms and conditions.
Verify and evaluate performance	The contract performance is evaluated by an independent third party, which should make the energy audit and evaluation report publicly available for public projects.

Possible challenges in implementing EPC and using ESCOs include: difficulty in obtaining financing from commercial banks, a lack of information on energy retrofit projects among energy performance contractors/ESCOs, lack of awareness of EPC/ESCOs in both the private and public sectors, lack of policies and support mechanisms, constraints on public- and private-sector capacity to seek out qualified EPC/ESCOs, a shortage of skilled personnel in the EPC/ESCO industry, a lack of common definitions and harmonized processes, and the long-term payback period for EPCs/ESCO services.

Monitoring Metrics

Some suggested measures for this recommendation are:

- Number of ESCO projects completed per year
- Number of ESCOs
- Size of ESCO projects (e.g., in square meters)
- Total investment and revenue of ESCO market
- Average energy savings per ESCO project
- Payback period of ESCO projects
- Kilowatt hour of annual electrical energy intensity per square meter (kWh_e/m^2), by type of building
- Kilowatt hour of annual heating energy intensity per square meter (kWh_t/m^2), by type of building
- Annual energy cost savings in renminbi, per square meter (RMB/m^2), by type of building

Case Studies

Chicago Guaranteed Energy Performance Contracting Program, USA

<http://www.sustainable-chicago.com/2008/04/23/green-building-and-climate-in-chicago/>

More than 70 percent of Chicago's greenhouse gas emissions are estimated to come from energy used in or by buildings (Johnston and Coffee, 2008). To address Chicago's contributions to climate change, the Guaranteed Energy Performance Contracting program aims to retrofit as many as 100 of the city's public buildings with lighting and mechanical equipment upgrades, and better water conservation technology.

Cumulatively, this program is expected to retrofit 6.5 million square feet (1.98 million m²) of office space and help create almost 375 direct jobs and 1,100 manufacturing and related jobs. Once complete, the energy retrofits will save taxpayers an estimated US\$4 million (28 million RMB)¹¹ to US\$5.7 million (40 million RMB) annually. To fund the program, Chicago needed to raise US\$40 million (278 million RMB) in private financing through the use of ESCOs, which guaranteed the energy savings. In 2009, the owners of Chicago's largest building, the Sears Tower, began planning a US\$350-million (2,433-million-RMB) energy retrofit. The retrofit would reduce electricity consumption by an estimated 80% and water consumption by 40%. Another building energy retrofit at the Richard J. Daley Center saves the city US\$600,000 (4.17 million RMB) a year.

London Public Building Retrofit Programme, UK

<http://www.london.gov.uk/priorities/environment/climate-change/energy-efficiency/buildings-energy-efficiency-programme>

The Greater London Authority created the RE:FIT Building Energy Efficiency Programme in support of the city's 2025 carbon dioxide (CO₂) emissions reduction target. The RE:FIT framework streamlines the procurement process for energy services by providing pre-negotiated contracts that comply with European Union regulations and can be used with a group of prequalified ESCOs for design and implementation of energy conservation measures. RE:FIT allows public-sector building owners to procure a supplier and implement retrofits as much as six times faster than they would be able to do using typical public-sector procurement. RE:FIT transfers the risk of project performance to the ESCOs, which must guarantee the energy savings to be achieved over an agreed payback period. ESCOs also bring leading-edge energy saving design and technology to the public sector. The pilot phase of this programme has identified energy savings of approximately 28 percent with a simple payback period of seven years, resulting in net savings of £1 million (9.7397 million RMB)¹² in fuel bills per year and more than 7,000 tonnes of CO₂ emissions reduction per year.

Energy Efficiency Retrofit Program, Houston, Texas, USA

http://c40.org/c40cities/houston/city_case_studies/city-of-houston-building-retrofit-case-study

With the support of the Clinton Climate Initiative (CCI), the Houston mayor's office has developed and implemented a large-scale energy-efficiency retrofit program for all city buildings with a goal of reducing energy demand from buildings by at least 25 percent. The city has partnered with two ESCOs, Siemens and Schneider, to employ a wide array of cost-effective measures to save energy. In accordance with CCI best practices, Siemens and Schneider agreed to guarantee the energy savings resulting from the project

¹¹ According to the World Bank official 2008 exchange rate: 1 USD = 6.95 RMB.
<http://data.worldbank.org/indicator/PA.NUS.FCRF>

¹² Base on the average yearly exchange rate from 3/11/2012 to 30/04/2013: 1 British Pound (£) = 9.7397 RMB.
<http://www.exchangerates.org.uk/GBP-CNY-exchange-rate-history.html>

over a period of up to 20 years; they also agreed to monitor savings in accordance with International Performance Measurement and Verification standards.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
< 1 year
- Co-Benefits
Reduced carbon emissions, improved air quality, enhanced public health and safety, increased employment opportunities, financial savings

Tools and Guidance

U.S. Department of Energy. Building Technologies Program. 2011. Sample solicitation and contracting document. September, 2011. Available at:

http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-21004.pdf.

Berliner Energieagentur GmbH. Programme for Environment Management and Sustainable Resource Use. International experience with the development of the ESCO markets. Available at:

<http://www.giz.de/Themen/en/SID-67B59468-94A47B78/dokumente/en-International-Experience-Developing-ESCO-Markets.pdf>.

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Johnston and Coffee, 2008. *Green building and climate in Chicago*. Accessed at November 30, 2012. Available at: <http://www.sustainable-chicago.com/2008/04/23/green-building-and-climate-in-chicago/>.

U.S. EPA, 2007. Introduction to energy performance contracting. October, 2007. Available at: http://www.energystar.gov/ia/partners/spp_res/Introduction_to_Performance_Contracting.pdf.

B06: Municipal Building Energy Efficiency Task Force

Description

For large cities that have numerous municipal buildings, establishing a municipal building energy-efficiency task force can accelerate implementation of energy-efficiency improvements in government buildings. If an energy-efficiency task force is responsible for coordinating all ongoing building energy programs and has a direct line of authority from the mayor, municipal building retrofit and upgrade programs can be implemented quickly, effectively, and in a coordinated manner. Such a task force can also help consolidate all municipal building energy-efficiency projects and thereby benefit from economies of scale while serving as a central point of contact for potential implementation partners (e.g., energy service companies [ESCOs]).

Implementation Strategies and Challenges

Implementation Activity	Description
Establish task force	Executive Order or legislative action can establish a task force that reports directly to the mayor with a mandate to identify and execute energy-efficiency projects in all municipal buildings. Budget for staff can come from mayor's discretionary funds.
Appoint task force leader	An individual is appointed to serve as task force leader. The leader can coordinate and facilitate all programs and projects and should have leadership skills, a wide network, and the ability to work across agencies to get the necessary approvals for energy upgrade projects.
Acquire technical capability	Staff members or outside consultants are hired who have technical expertise in a wide range of building energy systems and the ability to conduct audits, write Requests for Proposals for subcontractors or ESCOs, and manage construction and renovation projects.
Begin data collection	Basic information is collected on all municipal buildings (e.g., name, address, electric utility account #, electric and water bill data, etc.). The information is used for a review of all buildings to identify pilot projects.
Identify key energy-efficiency improvements	The task force recommends the energy-efficiency projects that will save the most energy and are politically feasible to implement.
Implement energy- efficiency projects	The task force oversees and manages the building energy-efficiency improvements, monitors progress, and evaluates the total energy saved.

Some possible challenges to establishing a municipal building energy-efficiency task force include: lack of information on current energy-efficiency levels of municipal buildings, lack of commitment by the mayor or municipal departments to support a task force, inability of task force leader to work across

municipal departments, inability of task force to effectively prioritize building energy-efficiency projects, lack of sufficient financial resources to implement building efficiency projects.

Monitoring Metrics

Some suggested measures for municipal building energy-efficiency task forces are:

- Number of energy-efficiency projects completed per year
- Number of energy-efficiency projects currently being carried out
- Total energy saved from projects implemented by task force
- Renminbi (RMB) saved per year by task force energy-efficiency projects

Case Studies

Ekurhuleni Metropolitan Municipality (EMM) Energy Efficiency Strategy, South Africa

http://www.pepsonline.org/publications/Ekurhuleni%20EE%20Case%20Study%204_06.pdf

Since June 2005, Ekurhuleni Metropolitan Municipality (EMM) has implemented cost-saving and energy-saving measures in three municipal headquarters buildings under the leadership of the municipal Environment and Tourism Department (taking on the role of an energy efficiency task force). An energy-efficiency retrofit strategy was developed involving a wide range of other municipal departments. The municipal building retrofit project included installation of renewable applications and high-efficiency, cost-effective lighting and water boilers in existing municipal buildings. The total cost of the project, including labor and equipment, was 249,120 Rand (R) (US\$41,063 or 327,272 RMB)¹³ and was funded through a grant from the United States Agency for International Development. The municipal retrofits saved 328,988 kilowatt hours (kWh) of energy and US\$50,664 (403,792 RMB) per year (using the value of \$US0.157/kWh or 1.251 RMB/kWh for Ekurhuleni Municipal Buildings under tariff C given by EMM). A simple payback period, taking into account the total investment, was 1.2 years. The retrofits can be considered a very cost effective and significant environmental achievement, especially taking into consideration the project's co-benefits: reduction of 308 tonnes of carbon dioxide (CO₂) equivalent, 3 tonnes of sulfur oxide, and 1 tonne of nitrogen oxide emissions.

Energy Management System, Frankfurt, Germany

<http://www.managenergy.net/download/r164.pdf>

In 1996, the City of Frankfurt's building department made energy efficiency a priority and contracted with a private company to install and operate an energy management system for the City Hall (Romer), the Paulskirche, and the Museum Schirn. The project goal was to reduce the city's energy and water costs as well as reduce CO₂ emissions. Based on the annual costs of 2.6 million Deutsche Marks (DM)

¹³ According to the World Bank official 2006 exchange rate: 1 USD = 7.97 RMB.
<http://data.worldbank.org/indicator/PA.NUS.FCRF>

(9.1832 million RMB)¹⁴ from 1992 to 1993, including an investment of 1 million DM (3.532 million RMB) for control equipment, potential cost reductions were estimated to be approximately 320,000 DM (1.13 million RMB) per year. Repayment of the invested capital will be from energy savings (54%) and lowered operating costs of the buildings (46%) over a period of eight years.

Energy Plan, Ann Arbor, Michigan, USA

http://www.a2gov.org/government/publicservices/systems_planning/energy/Pages/AboutTheEnergyOffice.aspx

The Ann Arbor Energy Plan was created in 1981 to establish goals and programs to reduce the city's energy use and costs while moving the city toward more sustainable energy use. The Ann Arbor Energy Office supports energy-efficient building projects for more than 50 municipal facilities, including overseeing a performance contracting retrofit of the city hall. An innovative Municipal Energy Fund has also been utilized to implement energy-efficiency improvements in more than 20 municipal facilities. In addition, the energy office obtained and managed more than US\$680,000 (4.29 million RMB)¹⁵ in grants and rebates from federal, state, and corporate sources. Some of these grants, such as Clean Cities grants, helped the Energy Office build partnerships among various municipal departments, levels of government, and public and private sectors in support of alternative fuel vehicles. In total, the city's energy office initiatives have saved city taxpayers more than US\$5 million (31.55 million RMB) in energy expenditures over the past decade.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
< 1 year
- Co-Benefits
Reduced carbon emissions, improved air quality, increased employment opportunities, financial savings, improved government efficiency.

¹⁴ According to the World Bank official 1992 exchange rate: 1 USD = 1.56 DEM and 1 USD = 5.51 RMB. Therefore, 1 DM = 3.532 RMB.

<http://data.worldbank.org/indicator/PA.NUS.FCRF>

¹⁵ According to the World Bank official 2012 exchange rate: 1 USD = 6.31 RMB.

<http://data.worldbank.org/indicator/PA.NUS.FCRF>

Tools and Guidance

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B07: Expedited Permitting for Green Buildings

Description

Local governments can prioritize green buildings at low or no cost by making simple modifications to the building project review process to expedite the permitting of green projects. An expedited permitting process makes construction of efficient and high-performance buildings an attractive option for developers. Review and permitting processes can vary greatly in length from one jurisdiction to another. In some cases, these processes can take months or even years, resulting in increased project costs, uncertainty, and delayed return on building project investments. Reducing the duration of the review and permitting process for verifiable green building projects can significantly reduce the developer's costs. In many cases, local governments may also offer additional incentives in the form of reduced or waived building review and permitting fees for green buildings. Expedited permitting allows a municipality to offer a significant incentive for green buildings at little or no cost because this strategy only requires a shift in permitting priority.

Implementation Strategies and Challenges

Implementation Activity	Methodology
Prepare design documents	Owners, architects, designers, engineers, contractors, or other project representatives prepare design and construction documents for the proposed green building project, verifying that the project complies with the national/local green building standards.
Submit to local government for review	Design and construction documents are submitted to the local government for review and permitting. Drawings submitted under the expedited permitting programs should be given the highest priority by permit review officials.
Issue permits	If any deficiencies are found during the permit review, they must be addressed by the design team, and the corrections certified by the government; then, drawings are approved, and permits are issued.

This policy recommendation can be implemented at low or no cost. It does not require additional regulatory effort because it only entails a shift in permitting priority. It can be implemented together with other financial incentives such as green building subsidies, rebates, and tax reductions.

Monitoring Metrics

Some suggested measures for expedited permitting for green buildings are:

- Number of green building projects receiving expedited permits
- Number of green building projects currently being carried out
- Increase in total number of green buildings after implementation of expedited permitting
- Total green building floor area after implementation of expedited permitting
- Kilowatt hour of annual electrical energy intensity per square meter (kWh_e/m^2), by type of building (schools, offices, residential, hospitals, etc.)
- Kilowatt hour of annual heating energy intensity per square meter (kWh_h/m^2), by type of building
- Renminbi per square meter (RMB/m^2) of annual energy cost, by type of building

Case Studies

Green Building Permits, Chicago, Illinois, USA

<http://www.sustainable-chicago.com/2008/04/23/green-building-and-climate-in-chicago/>

Chicago is the first U.S. city to offer an expedited building permit to encourage green buildings. Chicago's expedited building permit program streamlines the permitting process and provides financial incentives in the form of waived fees for qualifying building projects that incorporate green technologies, such as green roofs, rainwater harvesting, and building-integrated renewable technologies and that receive the U.S. Green Building Council's Leadership in Energy & Environmental Design (LEED) certification. Under this program, green building project developers can receive a permit in as few as 15 business days and can receive a partial waiver of consultant review fees of up to US\$25,000 (173,750 RMB).¹⁶ Through expedited permitting, the city has encouraged hundreds of projects representing more than 2 million square feet to build green. Chicago also has more than 250 buildings working toward LEED certification, more than in any other U.S. city. Chicago is also the only city in the world to have four LEED platinum buildings, the highest level of LEED certification.

Sustainable Building Expedited Permit Program, San Diego, California, USA

http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA235F

In 2002, the City of San Diego passed a resolution amending the city's Sustainable Building Policy to allow expedited permitting for sustainable buildings. The policy is scheduled to be revised every three years. Key elements of the San Diego Green Building Program are natural resource conservation,

¹⁶ According to the World Bank official 2008 exchange rate: 1 USD = 6.95 RMB.
<http://data.worldbank.org/indicator/PA.NUS.FCRF>

effective water management, and energy efficiency. To qualify for incentives, a project must comply with one of several conservation measures: inclusion of recycled-content materials or straw bale construction, inclusion of gray-water systems, or energy use below the California Energy Commission standards. Moreover, a project must utilize either solar photovoltaic (PV) to generate a "certain percentage" of the project's energy needs, or achieve LEED Silver certification. For example, city-owned new buildings are required to provide a minimum of 15 percent of total building energy using on-site self-generation from proven renewable energy technologies when site conditions and configuration allow for reasonable payback on the significant investment per San Diego Sustainable Building Policy No. 900-14. New residential, commercial, and industrial development projects that meet sustainable building criteria are all eligible for expedited permitting.

The expedited permitting process reduces the normal permitting processing time by an estimated 25%, saving developers seven to 10 days. Developers can also benefit from a 7.5% reduction in project plan review and building permit fees. By prioritizing green projects, the city saves customers building green single-family homes several weeks of processing time as well as several hundred dollars in fees. Homeowners and developers can also benefit from waived fees for the building permit and project plan review of residential solar PV systems

During the 2010-2011 Fiscal Year, the city waived more than US\$322,000 (2.08 million RMB)¹⁷ in building permit fees as incentives for renewable energy projects. During the same fiscal year, San Diego also waived permit fees for 952 solar PV panel installations and 29 solar water heater systems. All of these projects also benefited from expedited processing. Solar contractors, developers, and the general public have welcomed the fee waivers and time reductions and the relative ease of obtaining a permit. As a result, San Diego was designated one of the "Top 5 Solar Friendly Municipalities" by a 2009 report on solar electric permit fees in Southern California by the Sierra Club, an environmental organization. During the first three-quarters of 2011 alone, the city's LEED-certified buildings saved an estimated 4,865 tons of carbon dioxide emissions.

Green Building Program, Chandler, Arizona, USA

http://www.chandleraz.gov/Content/GB_Ch_GBP.pdf

The mayor and city council of Chandler, Arizona adopted Resolution 4199 in June 2008 to establish incentives for private-sector green buildings. As part of the resolution, permit applications for buildings that are pursuing Silver or higher certification under the LEED New Construction, Core and Shell, Commercial Interiors, or Schools programs will be granted an expedited review by the city. To be eligible, project teams must also include a LEED-accredited professional or hire a qualified consultant as part of the plan review process. Project developers must also submit a LEED checklist showing which LEED points are being pursued, and applicants must sign an agreement stating that projects will be built as indicated in the approved site plan. Eligible LEED-certified green building projects may also receive

¹⁷ According to the World Bank's official 2011 exchange rate: 1 USD = 6.46 RMB.
<http://data.worldbank.org/indicator/PA.NUS.FCRF>

financial incentives on a first-come, first-served basis. In Fiscal Year 2008-2009, for instance, a total of US\$50,000 (341,500 RMB)¹⁸ from the Green Building Program fund was set aside for reimbursing permitting fees. In addition, participating projects will be recognized with exterior signs and will be considered for the Chandler Architectural Excellence Award in the Green Building category.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
<1 year
- Co-Benefits
Reduced carbon emissions, improved air quality, increased employment opportunities, financial savings

Tools and Guidance

Department of Justice of State of California. State and local government green building ordinances in California. Available at: http://www.ag.ca.gov/globalwarming/pdf/green_building.pdf.

¹⁸ According to the World Bank 2009 official exchange rate: 1 USD = 6.83 RMB.
<http://data.worldbank.org/indicator/PA.NUS.FCRF>

B08: Targets for Efficiency and Renewables in Buildings

Description

There are four main types of target-based policies for the building sector: energy and/or carbon emission targets for new buildings, retrofit targets for existing buildings, broad voluntary and negotiated agreements on efficiency or low carbon targets, and dissemination goals for building technologies. In addition, targets for municipal buildings can help government to lead by example, spurring energy efficiency and use of renewable energy in other building sub-sectors.

For new building targets, all new construction typically must meet energy-performance or energy-reduction targets by a certain year. Energy targets for new buildings include the UK target for zero energy and zero-carbon-dioxide (CO₂) emission homes by 2016 and California's target for zero net energy¹⁹ in 100% of new residential construction by 2020 and 50% of existing commercial construction by 2030. China has also set a target of 65% reduction in the energy intensity of new construction relative to inefficient 1980s buildings in the severe cold, cold, and hot summer cold winter climate zones (MOHURD, 2012). Possible co-benefits of new building targets include creating employment and improving comfort and productivity.

Targets for retrofitting existing buildings may include overarching energy reduction targets for certain building types or total floor area targets for specific retrofit measures. One example of retrofit targets for existing buildings is California's zero net energy target for 50% of existing commercial buildings by 2030, with the actual change in total energy use of commercial buildings to be used as a performance metric (California Public Utilities Commission, 2008). The city of Chicago has set a target of auditing and retrofitting 15 million square feet (1.39 million square meters) of public buildings with efficient heating, ventilation, and air conditioning (HVAC) equipment and lighting (ICLEI, 2009). China has also set targets for total retrofit areas of 400 million square meters in the northern region and 50 million square meters in the hot summer/cold winter and hot summer/warm winter climate zones for envelope, heat metering, and heating network retrofit incentives. Co-benefits of setting retrofit targets include creation of employment and new business opportunities as demand for retrofitting grows. There can also be improvements in thermal comfort and social welfare and a reduction in poverty with new or expanded residential retrofit programs that specifically help low-income households reduce energy expenditures, such as in California's plan.

Broad voluntary and negotiated agreements on building targets are exemplified by the U.S. Mayors' Climate Protection Agreement (MCPA) that was set up in 2005. By 2015, nearly 300 mayors representing more than 49 million Americans in 44 states and Washington, D.C. have signed the MCPA. The agreement urges the federal and state governments to meet or exceed the target of reducing greenhouse gas emissions to 7 percent below 1990 levels by 2012. For the building sector, the MCPA encourages local governments to purchase only ENERGY STAR efficient equipment and appliances for

¹⁹ A zero-net-energy building employs a combination of energy-efficient design features, efficient appliances, clean distributed generation, and advanced energy management systems to result in no net purchases of energy from the utility grid (California Public Utilities Commission, 2008).

city use, and promotes sustainable building practices incorporated in the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) program or a similar green building program (ICLEI 2009).

Efficient building technologies, particularly building-integrated renewable technologies, can also be promoted through technology dissemination targets or goals, such as the California Solar Initiative (CSI), which set a target of installing 3,000 MW of solar photovoltaic (PV) capacity by 2018 and includes \$2.9 billion in economic incentives for building owners and homeowners to install solar PV systems (Go Solar California 2010). CSI also promotes the use of solar thermal systems and advanced metering in solar applications. Technology dissemination goals are often used in conjunction with fiscal policies, incentives, as well as state/city-wide energy-efficiency and emissions-reduction targets.

Implementation Strategy and Challenges

Implementation Activity	Description
Develop building energy baseline	Implementing agency gathers data, establishes baseline energy intensity/efficiency levels, and identifies energy-saving opportunities through energy audit and benchmarking studies.
Set a target	Based on the baseline, agency develops a target for the program.
Create action plan	Agency develops an action plan with specific timelines for meeting the target. On the basis of cost and energy savings potential, the agency prioritizes projects.
Implement improvements	Efficiency improvements and projects are implemented to reach target.
Track results	Agency establishes an energy measurement and reporting system to track results and progress toward the target.
Review, evaluate, and update	Agency reviews and evaluates the actual annual energy savings, performance metrics, and planned targets and updates action plan and targets as needed.

Some possible challenges to implementing this policy recommendation include: lack of data for setting an appropriate baseline and target; lack of a roadmap for integrating whole-system efficiency measures that bundles investment strategies and building types with strategic energy management principles and practices; lack of building owner motivation and/or resources to improve building energy performance; complicated, non-standardized measurement and verification of energy savings to help assess progress toward target; lack of shared knowledge, clear communication, or collaboration among key stakeholders; lack of localized, relevant financial best practices and tools.

Monitoring Metrics

Some suggested measures for targets are:

- Kilowatt hour of benchmark electrical energy consumption on a per-square-meter basis (kWh_e/m²)
- Kilowatt hour of benchmark heating energy consumption on a per-square-meter basis (kWh_h/m²)
- Benchmark energy cost in renminbi per square meter (RMB/m²) for all buildings
- % of target met for a given year
- Total energy savings from meeting target
- Total emissions reduction from meeting target

Case Studies

New building targets, Vancouver, Canada

<http://vancouver.ca/home-property-development/green-building-and-renovating.aspx>

The City of Vancouver is working to reduce by 33% by 2020 the amount of energy that new homes consume, with the goal of making all new buildings "carbon neutral" by 2030. At the same time, the city has set a target of reducing greenhouse gas emissions from existing buildings by 20% compared to 2007 levels. The city is implementing a wide range of green building programs and policies to help reach this ambitious target, including the Green Homes Program. Under the Green Homes Program, new single- and two-family homes are required to include a number of sustainable features to save energy, water, and money while providing a high-quality indoor environment. Houses are also required to be adaptable to future energy generation technologies as they become available, as well as to power the next generation of electric cars. The city provides homeowners with CAN\$7,000 (52,072 RMB)²⁰ in government rebates and loans of up to CAN\$16,000 (119,022 RMB) at 4.5% fixed interest over 10 years for completing select home energy upgrades through the Home Energy Loan Program. The Condo Energy Retrofit Pilot Program helps organize and fund building retrofits with financial incentives of up to CAN\$60,000 (446,334 RMB), including CAN\$15,000 (111,584 RMB) in lighting upgrades from British Columbia Hydro, CAN\$20,000 (148,778 RMB) for a solar hot water system, CAN\$15,000 (111,584 RMB) for five electric vehicle charging stations, and CAN\$10,000 (74,389 RMB) toward engineering design and installation costs. In addition, the Green Demolition Practices policy encourages careful disassembly of a building rather than simply demolishing it, to promote the reuse, recycling, and recovery of building materials.

Climate Action Plan Goals for Building Energy Use, Berkeley, California, USA

<http://www.ci.berkeley.ca.us/ContentDisplay.aspx?id=70982>

Emissions from energy use in Berkeley's homes, businesses, and institutions account for approximately half of total community emissions. The Berkeley Climate Action Plan sets the goal of reducing building energy use emissions by 35% below 2000 levels by 2020 and 80% by 2050. To achieve this goal, the city's Green Building Program includes a combination of minimum requirements and resources that encourage innovative strategies to minimize energy and water consumption, maximize recycling of

²⁰ According to the 2007 exchange rate: 1 CAD = 7.4389 CNY.
<http://www.oanda.com/currency/historical-rates/>

construction debris, and create healthy and comfortable indoor environments. For instance, the government requires all green building projects to reduce storm water pollution, account for potential ecological impacts on nearby creeks and adjacent property, and comply with California's Title 24 Energy Efficiency Standard. In addition, specific requirements apply to large commercial projects and renovations valued at US\$50,000 (315,500 RMB)²¹ or more, renovations valued at US\$100,000 (631,000 RMB) or more, and transfer of property ownership. Achievements under Berkeley's Climate Action Plan for Building Energy Use include: (1) total greenhouse gas emissions from building energy use decreased approximately 1% between 2000 and 2010; (2) total residential energy use decreased 10% from 2000 to 2010; (3) commercial electricity use reduced by 7% from 2000 to 2010 (commercial natural gas use increased 10%); (4) 790 solar photovoltaic (PV) systems had been installed as of June 2011; and (5) 78 solar thermal hot water systems had been installed as of 2010.

Existing Building Renewal Initiative, Northwest Energy Efficiency Alliance, USA

<http://www.betterbricks.com/design-construction/existing-building-renewal-initiative>

The existing commercial building stock in the U.S. Northwest consumes 40% of all electricity loads in that region and offers a significant energy-savings opportunity to improve bottom line and asset values for building owners and reduce costs for business tenants. Through the Better Bricks program, the Northwest Energy Efficiency Alliance (NEEA) is developing a regional Existing Building Renewal initiative to help building owners, managers, and tenants conduct deep, whole-building energy-efficiency retrofits. The Existing Building Renewal initiative will motivate and guide owners and design and construction teams to revamp the existing building stock to achieve energy savings of 30% or more, ideally aiming for 2030 Challenge targets of 50% or more. According to a NEEA's evaluation report on nine existing buildings that underwent deep efficiency projects, seven of the nine saved 50% more energy than the national average and have an average energy use intensity²² of just 123 kilowatt hours per square meter per year.

Attributes

- Carbon Savings Potential
Medium
- First Cost to Government
Low
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced carbon emissions, improved air quality, increased employment opportunities, fuel savings

²¹ According to the World Bank's official exchange rate of 2012: 1 USD = 6.31 RMB.
<http://data.worldbank.org/indicator/PA.NUS.FCRF>

²² Energy Use Intensity is the total annual energy (gas and electricity) used in a building.

Tools and Guidance

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B09: More Stringent Local Building Codes

Description

Building energy codes are intended to reduce the energy load of buildings. Codes typically specify requirements for thermal resistance in the building shell and windows, minimum air leakage, and minimum heating and cooling equipment efficiency. These measures can help eliminate inefficient building designs, applications, and technologies with modest or no increases in up-front project costs. Mandatory building energy codes establish a minimum “floor” for building energy performance. Building codes set basic energy-efficiency requirements for buildings by requiring that specific energy-efficiency measures be implemented at the time of construction or that buildings meet a certain level of energy performance. The effectiveness of building energy codes in reducing energy consumption and carbon emissions is depends on consistent code review and updates and effective enforcement to ensure full compliance.

Building energy codes work to overcome the substantial market barriers to energy efficiency in new buildings. Energy codes are typically developed at the national level, adopted at the state level, and implemented and enforced by local governments. However, stringent regional building energy codes have been developed and adopted, for example in the U.S. state of California and in major Chinese municipalities. Local governments can adopt and enforce building energy standards before the statewide standards effective date, require additional energy conservation measures, and/or set building energy standards that are more stringent than national requirements, taking the lead and making local buildings more efficient than required by national building energy-efficiency standards.

Implementation Strategies and Challenges

Implementation Step	Description
Assess building energy-saving opportunities and develop baseline	Local code agency assesses the climate, building types, real estate market, available technologies and designs, and construction industry to identify building efficiency improvement opportunities. Agency evaluates other building guidelines in the region and globally, identifies the most relevant strategies, and develops a baseline for the building energy code.
Issue local building energy code	Based on assessment of other building guidelines and local conditions, local municipalities may adopt either the existing national or regional building energy code requirements or a more stringent standard for new buildings in the city.
Incorporate building energy code requirements into broader framework for building code implementation	After the building energy code is in effect, it is necessary to incorporate the energy requirements into the existing building code implementation process (e.g., add energy requirements to building permit reviews).

Conduct compliance verification and certification	Compliance verification and certification determine whether buildings are constructed in accord with code. If they are not, punitive measures need to be considered, and additional enforcement and training initiatives may be needed.
Evaluate building energy code implementation process and energy savings	Evaluating the implementation process and estimated energy savings ensures that requirements are followed and stated goals achieved. Both process and outcome evaluation can be used to determine the effectiveness of the local government's enforcement efforts.

Potential implementation challenges include: controversy in determining an accurate and appropriate baseline for the building energy code because of resistance from developers and stakeholders; low building code compliance because of low government priority, insufficient resources, or pressure from vested interests; limited knowledge and capacity among stakeholders; inconsistencies in interpretation and application of building energy code requirements.

Monitoring Metrics

Some suggested measures for more stringent local building code are:

- Compliance rate
- Percent energy savings relative to baseline or national standards (previous versions of code)
- Kilowatt hour of benchmark annual electrical energy consumption on a per-square-meter basis, (kWh_e/m^2), for all municipal buildings in the city
- Kilowatt hour of benchmark annual heating energy consumption on a per-square-meter basis (kWh_h/m^2), for all municipal buildings in the city
- Renminbi of benchmark energy cost on a per-square-meter basis (RMB/m^2), for all municipal buildings

Case Studies

State of California Title 24, USA

<http://www.energy.ca.gov/title24/>

California was the first U.S. state to include energy requirements in its building code, starting in 1978. California Title 24 is an important document that mandates conservation of energy consumed as well as standards for construction and maintenance, life and fire safety, green design, and accessibility. Title 24 is composed of the following main codes: (1) the California Building Code, which regulates structure, size,

and design of construction or alteration of any building within the state; (2) the California Energy Code, which is the basis for inspections and controls on usage, distribution, and conservation of energy in buildings within California; (3) the California Plumbing Code, which controls usage and conservation of water in buildings; (4) the California Fire Code, which establishes measures to prevent fires and protect occupant safety during fires in buildings. These regulations are adopted by all counties and cities within the state, together with other local standards that may be enforced by the counties.

Although the Title 24 standards are uniform for all cities and counties, local cities and counties are allowed to add more restrictive regulations depending on their geological, climatic, and topographical conditions. These more restrictive regulations must be reported and filed with the California Energy Commission. In 2005, California's building energy code was estimated to have reduced annual energy demand by 180 megawatts (MW) with saving US\$43 billion (352.17 billion RMB)²³ in electricity and gas costs by 2011. Today, Title 24 is generally considered to be the most stringent and best enforced energy code in the nation, with field inspections to verify compliance. The state is continuing to strengthen the building energy code with more stringent standards requiring 25% energy reduction in lighting, heating, cooling, ventilation, and water heating adopted in 2013 (California Energy Commission 2012).

Comparisons of California's 2013 Title 24 with comparable model standards for commercial and residential buildings have found that Title 24 is significantly stricter than national and international model building energy codes. For commercial buildings, the 2013 California standard under Title 24 required an additional 12% reduction compared to the national standard, American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) 90.1-2010 (California Energy Commission 2013). For residential buildings, the 2013 Title 24 required additional 5% energy reduction compared to the 2012 International Energy Conservation Code (California Energy Commission 2013).

City of Seattle, Washington Energy Code, USA

http://www.seattle.gov/dpd/Codes/Energy_Code/Overview/history.asp

The city of Seattle has been recognized for its leadership in adopting and enforcing energy codes. The first comprehensive Seattle Energy Code took effect in 1980, but Seattle has had a residential insulation requirement since 1974, and the city's first furnace sizing and dust insulation requirement took effect in 1927. Seattle's building energy code is 20% more stringent than the state's building energy code. The Seattle department of planning and development has 27 code officials for both the general building code and the building energy code. In 2005, the department had 7,000 applications for plan review and conducted 80,000 inspections. Plan review of multi-family and commercial projects is handled by specialized energy personnel, who also serve as technical resources for other staff. Small residential projects and all construction inspections are handled by staff with similar specialties. Public workshops are held for architects, designers, and trade associations. A 20% share of the overall building permit fee

²³ According to the World Bank official 2012 exchange rate: 1 USD = 8.19 RMB.
<http://data.worldbank.org/indicator/PA.NUS.FCRF>

(0.5% of construction value, totaling US\$10 million (81.9 million RMB) in 2005) is used to build capacity and expertise for new code requirements. The publicly owned electric utility also provides funds for additional building energy code compliance staff. Seattle's successful experience of enforcing building energy codes suggests that compliance is more likely when the same rules apply equally to all, and codes are enforced equally for all buildings.

Tianjin building energy code, China

<http://www.tjrd.gov.cn/flfg/system/2012/05/15/010010373.shtml>

The city of Tianjin developed, under China's Energy Conservation Law and Civil Building Energy Code, a local building energy code that took effect on July 1, 2012. This code includes stringent energy-efficiency requirements for new buildings, green buildings, and existing buildings. It requires a 75% reduction relative to inefficient 1980s buildings in allowable heating intensity, which is more stringent than the national requirement for that climate zone. Building energy savings are incorporated into the assessment of the municipality's total energy savings target. A special fund will be allocated for building energy standards and codes to encourage existing building renovation and promote green building development as well as pilot projects. The municipal Wall Material Innovation and Building Energy-Efficiency Management Institute are responsible for monitoring the enforcement of the building energy code; evaluating building energy consumption; and providing training and guidance to architects, designers, and owners. A penalty of 200,000-500,000 RMB can be charged for those who adopt prohibited techniques, materials, and equipment. For those who violate the requirements for building engineering quality and heat metering standards, a penalty of 2-4% of the project's contract price is charged.

Attributes

- Carbon Savings Potential
High
- First Cost to Government
Medium
- Speed of Implementation
3 years
- Co-Benefits
Reduced carbon emissions, reduced air pollution, improved thermal comfort, efficient water use, increased employment opportunities for installing equipment and monitoring building compliance, financial savings

Tools and Guidance

California Energy Commission. 2012. 2013 Building Energy Efficiency Standards: Frequently Asked Questions. Sacramento, California: California Energy Commission.

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B10: Green Building Guidelines for New Buildings

Description

City-specific green building guidelines or certification programs can encourage greater construction of green buildings and use of green building technologies. Local guidelines can be based on previously established systems, for example the U.S. Leadership in Energy and Environmental Design (LEED) program, the UK Building Research Establishment Environmental Assessment Method (BREEAM) program, Japan's Comprehensive Assessment System for Built Environment Efficiency (CASBEE) program, Singapore's Green Mark program, and Abu Dhabi's Estidama program. Green building guidelines address energy efficiency as well as water conservation, urban heat island effects (green roofs), indoor air quality, materials efficiency, and other environmental aspects of buildings. A green building program can take many forms, including voluntary guidelines, mandatory minimum building standards, and incentives for private developers. The benefit of green building programs is that they promote energy-efficient and environmentally friendly buildings that save money and water and are high-quality environments in which to live and work.

Implementation Strategy and Challenges

Implementation Step	Description
Assess opportunities	Implementing agency assesses the climate, building types, real estate market, and construction industry for green building opportunities in the city. The agency also evaluates other green building guidelines in the region and globally and identifies the strategies most relevant to local needs.
Perform cost - benefit analysis (optional)	Agency assesses the general costs in the city of each potential green building strategy, including the cost of new construction to meet current code and the cost to meet the proposed green building design guidelines. This analysis should provide ranges of additional costs, savings, and co-benefits of the strategy beyond purely financial benefits.
Draft guidelines (voluntary approach)	Agency creates custom, city-specific green building design guidelines, taking into consideration unique local conditions of the city (climate, construction practices, safety, financial and market issues, etc.). Design guidelines can be introduced and promoted to the public to encourage voluntary adoption by progressive developers, designers, and building owners.
Draft incentive program (incentivized approach)	Along with the design guidelines, agency creates a program to incentivize exceptional green building designs by providing tax credits, zoning benefits, expedited permit approvals, or other tertiary benefits for green construction to which developers will respond.

Draft green building code (mandatory approach)	If a voluntary approach or an incentive-based approach is unlikely to succeed, or if the city wishes to have a mandatory program to promote green buildings, the agency incorporates the guidelines into existing local building codes.
Public outreach	City distributes the draft guidelines to the real estate, construction, and design communities, as well as city residents for comment.
Enact green building ordinance	With public comments integrated, a full set of technical and financial analysis completed, and potentially a small number of demonstration projects as benchmarks for reference, the city enacts a law, ordinance, or executive order to implement the green building guideline/incentive program/code.

Implementation challenges for green building guidelines can include: building industry resistance to green buildings because of likely higher up-front costs, lack of awareness of voluntary guidelines and incentive programs, and limited technical capacities to assist green building designers and developers.

Monitoring Metrics

Some suggested measures for this recommendation are:

- Kilowatt hours of benchmark electrical energy consumption per square meter (kWh_e/m^2)
- Kilowatt hours of benchmark heating energy consumption per square meter (kWh_h/m^2)
- Benchmark energy cost, in Renminbi, per square meter (RMB/m^2), for all buildings
- Number of buildings certified under new/other codes
- Total floor space areas (m^2) of certified green buildings
- Share of certified green buildings in city's total building floor space

Case Studies

Austin Energy Green Building (AE/GB), Austin, Texas USA

<http://www.austinenergy.com/energy%20efficiency/Programs/Green%20Building/index.htm>

In 1991, Austin Energy Green Building (AE/GB) developed the first city-wide tool for evaluating the sustainability of U.S. buildings. The tool is made up of four programs that cover single-family homes, commercial buildings, multi-family buildings, and governmental or utility buildings. The AE/GB tool helps transform the market by providing technical support to homeowners as well as architects, designers, and builders of sustainable buildings. Using green building rating tools developed specifically for Austin, along with the LEED and Green Globes national rating tools, AE/GB staff assist design teams in establishing green building goals and then review plans and specifications, make recommendations for improvements, and rate the impact of the final design on the environment and community.

AE/GB has saved US\$2.2 million (13.9 million RMB)²⁴ annually in reduced energy costs to consumers. The initial project investment of US\$1.2 million (6.4 million RMB)²⁵ came from the city's annual budget (including a US\$50,000 [266,000 RMB] grant from the U.S. Department of Energy). The AE/GB tool has also reduced energy consumption by 142,427 megawatt hours and reduced demand on utility generation resources by 82.8 megawatts. These energy savings reduced power plant carbon dioxide (CO₂) emissions by 90,831 tons, nitrogen oxides (NO_x) by 87.6 tons, and sulfur dioxide (SO₂) by 17.4 tons.

Sustainable Building Action Plan, Seattle, Washington, USA

<http://www.seattle.gov/dpd/GreenBuilding/OurProgram/Programhistory/default.asp>

Under the Sustainable Building Policy, Seattle requires that all new city buildings larger than 5,000 square feet (approximately 464.5 square meters [m²]) meet new state LEED sustainable building ratings.

The city provides financial, height, and density bonuses for private projects meeting LEED through programs such as: the Sustainable Building Action Plan (which contains key strategies to promote green buildings), the density bonus (offering eight and/or floor area greater than specified in the code to downtown commercial, residential, and mixed-use developments achieving LEED silver or higher), and the city's LEED Incentive Program (providing financial incentives for energy conservation, natural drainage/water conservation, and design and consulting fees for LEED projects).

Between 2001 and 2005, the city provided incentives of more than US\$4.3 million (35.2 million RMB)²⁶ for projects implementing LEED standards. The standards have produced average 35% reductions in energy use and saved 6.9 million kWh annually. Other benefits from the scheme include an average reduction of 1,067 CO₂ equivalent tonnes per LEED building along with average annual financial savings of US\$43,000 (352,170 RMB) per LEED building.

Green Building Guidelines, Cape Town, South Africa

[http://www.capetown.gov.za/en/EnvironmentalResourceManagement/publications/Documents/DRAFT City of Cape Town Green Building Guidelines.pdf](http://www.capetown.gov.za/en/EnvironmentalResourceManagement/publications/Documents/DRAFT%20City%20of%20Cape%20Town%20Green%20Building%20Guidelines.pdf)

The City of Cape Town enacted a bylaw in June 2012 calling for environmentally friendly building methods. Green Buildings Guidelines will form the core of the bylaw and are intended to actively promote resource-efficient construction of new or renovated buildings in Cape Town to minimize the negative environmental impacts of buildings while maximizing positive social and economic impacts. In

²⁴ World Bank official exchange rate of 2012: 1 USD = 6.31 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

²⁵ World Bank official exchange rate of 1991: 1 USD = 5.32 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

²⁶ World Bank official exchange rate of 2005: 1 USD = 8.19 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

the long term, the city plans to work toward design manuals and legislation to ensure construction of green buildings.

The green building guidelines are specific to Cape Town, including advice on site selection, design and construction, sustainable resource management, waste management, urban landscaping, human health and safety, and visual mitigation measures. The Green Building Guidelines document is also aligned with the policies of the Green Building Council of South Africa, which has incorporated the Green Star Rating system of the Green Building Council of Australia. The City of Cape Town will also likely incorporate the Green Star Rating system in the future.

Attributes

- Carbon Savings Potential
Medium
- First Cost to Government
Low
- Speed of Implementation
<1 year
- Co-Benefits
Reduced carbon emissions, efficient water use, increased employment opportunities, financial savings

Tools and Guidance

U.S. Environmental Protection Agency. 2010. *Sustainable design and green building toolkit*.
<http://www.epa.gov/region4/recycle/green-building-toolkit.pdf>.

B11: Financial Incentives for Distributed Generation in Buildings

Description

Distributed generation, also called on-site generation or decentralized generation, refers to generation of electricity from sources that are near the point of consumption, in contrast to centralized generation sources such as large utility-owned power plants. Clean distributed generators installed by residential and commercial buildings can supply electricity alone (via renewable generation or electricity), or heat or steam (via small combined heat and power [CHP] arrangements). Distributed generation reduces the amount of energy lost when power is transmitted over large distances and reduces the size and number of power lines that must be constructed. In addition, CHP is more energy efficient than generating electricity and thermal energy separately because, in a CHP system, heat that would normally be wasted in conventional power generation is recovered to meet heating demand. With distributed generation systems, property owners generate their own power and are also connected into the national grid. Owners use their self-generated power, but if they generate more power than they need, the excess may be supplied to the interconnected grid through an import/export meter; a credit is given for the power that is supplied.

Local and city governments can promote installation of distributed generation in new or existing buildings by providing financial incentives such as preferential loans, rebates, subsidies, or grants to building developers or owners. These financial incentives offset part of the higher up-front cost of installing distributed generation. Financial incentive programs have been established internationally to promote distributed generation in buildings. In the U.S., 609 federal, state, and utility rebate programs and 53 grant programs were offered for distributed generation in buildings as of January 2007. There are also U.S. federal tax credits for CHP investments.

California's Self-Generation Incentive Program provides incentives to customers who produce electricity from a variety of sources, including CHP. Incentive payments range from US\$0.50/W (3.2 RMB/W)²⁷ to US\$2.25/W (14.2 RMB/W), depending on the type of system. Japan has increased national solar photovoltaic (PV) subsidies for schools, hospitals, and railways stations from 33 to 50 percent in addition to providing subsidies for households. Ireland, Germany, and Luxembourg provide subsidies or grants for installation of solar water heaters and solar space heaters in residential, public, and commercial buildings. Eskom, the South African utility company, recently started a solar hot water subsidy program that provides US\$200-350 (1262-2209 RMB) per household and indicated a payback period of 5 to 8 years.

²⁷ World Bank official 2012 exchange rate: 1 USD = 6.31 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>.

Implementation Strategies and Challenges

Implementation Activity	Description
Identify target technology for subsidy	City government entities offering financial incentives defines qualifying distributed generation technology types (such as solar PV, solar water heater, fuel cell, micro-CHP and so on) and criteria for subsidy.
Determine financial incentive approach	City government entities can promote installation of distributed generation technologies in new or existing buildings by providing financial incentives such as preferential loans, rebates, subsidies, or grants to building developers or owners.
Determine appropriate incentive level	City government entities offering financial incentives determines amount of financial incentives based on analysis to identify minimum amount needed to incentivize investment and spur market transformation.
Develop channels for incentives	City government entities offering financial incentives works with relevant stakeholders to develop channels for applying for and receiving financial incentives.
Promote and market incentives to the public	Entity offering incentives launches information campaigns and related media outreach to inform public about availability of incentives.
Disburse payment	After verification of performance and other documents, entity offering incentives disburses subsidy/rebate/loan to applicants.

Implementation Challenges: lack of funding for grants, which are essential in developing countries where the first-cost barrier to distributed generation can be higher than in developed countries; lack of consumer awareness and understanding of distributed generation technologies; low electricity prices (especially if subsidized) and uncertainty around the future growth of business dampen the motivation of consumers and businesses to adopt new distributed generation technologies.

Suggested Monitoring Indicators

Some suggested measures for distributed generation programs are:

- Kilowatt hour of benchmark electrical energy consumption and generation on a per-square-meter basis (kWh_e/m^2)
- Kilowatt hour of benchmark heating energy consumption and generation on a per-square-meter basis (kWh_t/m^2)

- Benchmark energy cost in renminbi, on a per-square-meter basis (RMB/m²), for all buildings
- Annual increase in number of distributed generation projects
- Annual financial savings
- Reduced carbon dioxide emissions

Case Studies

Solar Grant Program, Boulder, Colorado, USA

http://www.bouldercolorado.gov/index.php?option=com_content&task=view&id=7700&Itemid=2845

The Solar Grant Program provides grants for PV and solar water heating installations in housing enrolled in the city's affordable housing program, site-based non-profit organizations, and low- to moderate-income housing owned and/or developed by a non-profit organization. Past solar grants ranged from US\$1,600 (10,096 RMB)²⁸ to US\$30,000 (189,300 RMB). Individual grant amounts are determined on a case-by-case basis but generally do not exceed 50% of the total out-of-pocket costs for the project after all rebates, tax credits, and other incentives are subtracted. Income tax must be paid on the grant amount in the year received.

Funding for Boulder's Solar Grant Program comes from revenue generated through local sales and use taxes on solar technologies. Boulder City Council members approved the city's renewable energy fund in November 2006. Since the first solar grant cycle in March 2008, more than US\$270,000 (1,703,700 RMB) has been awarded to non-profit groups and homeowners. Workers involved with the program estimate that grant recipients save more than US\$50,000 (315,500 RMB) annually in electricity and heating bills. As of January 2012, grant recipients had installed about 435 kilowatts worth of PV solar panels and two solar thermal systems.

Smart Buildings Detroit Green Fund Loan, Detroit, Michigan, USA

http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MI114F&re=0&ee=0

The Economic Development Corporation of the City of Detroit offers financial assistance to commercial, institutional, and public buildings in Detroit that install energy-efficiency and renewable energy technologies. Loans are available for up to 40% of the cost of eligible improvements, up to US\$100,000 (631,000 RMB). Eligible distributed generation technologies include solar panels, geothermal installations, wind, hydroelectric, and thermal load reduction projects. Other technologies may also be eligible for funding.

²⁸ According to the World Bank official 2012 exchange rate: 1 USD = 6.31 RMB.
<http://data.worldbank.org/indicator/PA.NUS.FCRF>

For instance, Newberry Hall Development, LLC is renovating a three-story residential building at 100 E. Willis Street. The owners will use the US\$100,000 (631,000 RMB) in grant funds to help pay for both energy-efficiency and distributed generation measures, including: insulation; weather stripping; window replacement; new heating, ventilation, and air conditioning equipment with geothermal components; lighting replacement; and low-water-flow toilets. Overall, the energy-saving improvements are expected to cost US\$561,000 (3.54 million RMB).

Solar Energy Grant Program, Maryland, USA

<http://www.thesolar411.com/energy-rebates-tax-credits/renewable-energy-incentives-md/>

Maryland's Solar Energy Grant Program, administered by the Maryland Energy Administration, provides financial incentives to homeowners, businesses, local governments, and non-profit organizations that install solar water-heating systems or solar-electric (PV) systems. Both grid-connected and off-grid PV systems are eligible for support. This program, which took effect in January 2005, replaced the state's expired "Clean Energy Incentives" tax credit for solar energy equipment. The first three rounds of program funding supported more than 200 projects.

The current Solar Energy Grant Program (effective for applications received on or after September 1, 2009) provides incentives as follows:

- Solar water heating: lesser of US\$2,000 (13,660 RMB)²⁹ or 30% of the installed cost
- Solar PV: US\$1.25/Watt (W) (8.5 RMB/W) for first 2 kilowatts (kW); \$0.75/W (5.1 RMB/W) for next 6 kW; and \$0.25/W (1.7 RMB/W) for next 12 kW

Thus, the maximum rebate is US\$10,000 (68,300 RMB), and systems must be 20 kW or smaller to qualify for a rebate.

In the past, this program has been funded almost entirely by appropriations from the state's General Fund. However, more recently, appropriations have been supplemented by funds raised through carbon emission allowance auctions as part of the Regional Greenhouse Gas Initiative and by federal economic stimulus money. The Fiscal Year 2010 (FY10) budget of \$5.8 million (39.3 million RMB)³⁰ for PV, solar thermal, wind, and geothermal rebates was funded entirely by the state Strategic Energy Investment Fund and American Recovery and Reinvestment Act proceeds.

²⁹ World Bank official 2009 exchange rate: 1 USD = 6.83 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

³⁰ World Bank official 2010 exchange rate: 1 USD = 6.77 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

Attributes

- Carbon Savings Potential
Medium
- First Cost to Government
Medium
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced carbon emissions, improved air quality, increased employment opportunities, fuel savings, reduced need for new transmission and distribution

Tools and Guidance

Lawrence Berkeley National Laboratory. Distributed energy resource customer adoption model (DER-CAM). Available at: <http://der.lbl.gov/der-cam>.

U.S. Environmental Protection Agency. Combined heat and power partnership. Available at: <http://www.epa.gov/chp/basic/index.html>.

B12: City Energy and Heat Maps

Description

Cities across the globe are developing plans to reduce their energy consumption and lower their carbon footprints by reducing energy-related greenhouse gas emissions. Although initial efforts have focused on individual buildings (for example, incorporating energy-efficient lighting, windows, and building systems), deeper reductions will call for changes beyond individual buildings, requiring a rethinking of how future infrastructure and energy policies should evolve.

A Geographical Information System (GIS)-based energy and heat map can help city officials target areas where they can achieve the most energy savings and carbon emission reductions. Specifically, an energy map of a city can provide information about energy use, renewable energy resources, infrastructure, carbon dioxide (CO₂) emissions sources, and can be a useful tool for decision makers to develop an energy plan and for residents to understand what is happening in their city in terms of current energy use and supply. Similarly, a heat map of the city can be used to identify areas where insulation could reduce energy use, to recognize available energy resources for distributed generation, and to identify areas where energy and financial savings are possible. Energy and heat maps have been widely developed by cities and regions in U.S. and Europe for energy and low-carbon planning.

Implementation Strategy and Challenges

Implementation Step	Description
Establish work team	The government establishes a work team of staff experienced in GIS and allocates funding.
Discuss map usage	The work team should understand the intended use of the energy and/or heat map and decide what information and elements the map will provide.
Gather data	The work team gathers data (e.g., electricity, heat, natural gas, steam, oil usage in each district of the city) based on the purpose of the map and data availability from relevant agencies.
Develop model	The work team develops a model for the map to be interactive, reflecting energy use, resource supply, estimated costs, and CO ₂ emissions.
Publish on line	The interactive map should be made publicly available on line.
Review and update	The work team should continuously check the availability and accuracy of the data and update the map to reflect the most recent and more comprehensive information as it becomes available.

Implementation Challenges can include: lack of technical capacity and staff for creating maps, limited data availability or poor data quality with low accuracy and resolution, lack of ability to use/interpret map.

Monitoring Metrics

Some suggested measures for this recommendation are:

- Data accuracy
- Data scope
- Data timeliness
- Data spatial resolution
- Other categories of data that can be applied to the map

Case Studies

Silicon Valley Energy Map, Santa Clara, California, USA

<http://energy.sanjoseca.gov/svenerymap.asp>

The Silicon Valley Energy Map is a publicly available on-line tool produced by the Silicon Valley Energy Watch, a partnership between the City of San Jose and the Pacific Gas and Electric Company (PG&E) that serves all of Santa Clara County with outreach about energy efficiency. The map provides information about energy use, solar and renewable energy, and green buildings in Santa Clara County. The map enables residents to visualize what is happening in their community in terms of building energy use, solar energy, and green building. The map also helps the community engage in a dialogue and ask relevant questions about energy use in the community and to see how energy use can be improved. In addition, the map offers an understanding of how to direct clean energy efforts.

Renew Boston Solar, Boston, Massachusetts, USA

<http://gis.cityofboston.gov/solarboston/#>

The City of Boston created the Renew Boston Solar map to assist in tracking the community's progress toward meeting its goal of reducing greenhouse gas emissions by 25% in 2020. Boston is partnering with the Boston Redevelopment Authority and Department of Innovation and Technology to create an on-line map of solar, wind, and other renewable energy projects throughout Boston. Renew Boston Solar is a partner of the U.S. Department of Energy's Sun Shot Initiative which aims to dramatically decrease the total costs of solar energy systems.

London Heat Map, London, England, UK

<http://www.londonheatmap.org.uk/Content/HeatMap.aspx>

The London Heat Map is an interactive GIS tool that allows users to identify opportunities for decentralized energy (DE) projects in London. The map builds on the 2005 London Community Heating Development Study and provides spatial intelligence on factors relevant to the identification and development of DE opportunities, such as: major energy consumers, fuel consumption and CO₂ emissions, energy supply plants, community heating networks, and heat density. The map is publicly accessible to anyone with an interest in DE. Local authorities can use the map as the starting point to developing detailed energy master plans to inform DE policies climate change strategies. Developers can use the map to help them meet London Plan DE policies.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
<1 year
- Co-Benefits
- Increased public awareness and education, better planning and implementation

Tools and Guidance

National Renewable Energy Laboratory. Dynamic maps, GIS data and analysis tools. Available at: <http://www.nrel.gov/gis/>.

ESRI. Mapping Center. Available at: <http://mappingcenter.esri.com/index.cfm?fa=home.welcome>.

B13: Building Energy Labeling and Information Disclosure

Description

Similar to the way labels are used to rate the energy efficiency of equipment, labels are also used to rate the energy performance of buildings. Labels compare a building's energy performance to that of other similar buildings, using a theoretical (or design) rating or a measured (or operational) rating. A theoretical rating label is based on a building's design and installed technologies and does not consider actual energy consumption; this label can be earned as soon as building construction is completed and does not depend on the behavior of building occupants. A measured or operational rating label is based on an occupied building's actual energy performance and requires energy measurements and audits to determine actual energy consumption. Both design and operational rating labels for buildings have been adopted worldwide, including in the United States, China, and the European Union. Endorsement labels identify buildings that are rated to be at or above a certain efficiency level but do not provide information on a building's specific energy performance. A prominent example of a building endorsement label is the U.S. ENERGY STAR label for new homes and commercial buildings. In addition to building energy labeling programs, some countries, such as Australia, have also adopted building energy disclosure requirements specifying that a building's energy consumption be revealed to potential buyers or tenants prior to a sale or rental. Although building labeling and information disclosure programs are typically administered at the national level, local governments can play a role by incentivizing or requiring the use of voluntary building labels and/or building information disclosures within their jurisdiction. Expanding the use of building labels and information disclosure can help provide local building buyers and tenants with more information and accelerate building market transformation.

Implementation Strategies and Challenges

Implementation Step	Description
Assess current status of building stock	Before implementing building energy-efficiency labels, the implementing agency surveys the performance of the existing building stock as a basis for setting appropriate baseline energy label thresholds and developing modeling tools that accurately evaluate a building's energy performance within a reasonable time frame and at reasonable cost.
Design and implement a labeling program	Based on the analysis of existing building energy-efficiency levels, the agency designs and implements the building labeling program.
Accept applications for building energy-efficiency label	Owners benchmark their buildings and then submit application documents describing the designed energy performance of the building.
Review and verify the design and/or	The agency reviews the application documents and

operational energy performance	verifies that the building's design or operational performance after construction (or a minimum period of operation) matches the performance described in the application documents.
Issue a certificate	After reviewing documents and verifying the building's design and/or operational performance, the agency issues a certificate to the building owner.
Evaluate the labeling program	The agency monitors the program's performance, adapts the program to changing circumstances, and demonstrates to funding agencies and the public that the expected benefits are being achieved.

Implementation Challenges: lack of sufficient technical capacity (staff, modeling tools) and knowledge to accurately evaluate and rate buildings, lack of available staff and resources to verify building performance and ensure label accuracy, lack of industry and public awareness and understanding of labeling programs, increased transaction costs of applying for a building label, differences between actual performance of buildings and theoretical ratings

Monitoring Metrics

Some suggested measures for this recommendation are:

- Number of projects completed per year
- Number of projects currently being carried out
- Change in market share of buildings with higher efficiency ratings
- Market share of buildings with voluntary endorsement label
- Energy saved per square meter (m^2), in kilowatt hours (kWh), of labeled versus average building
- Annual electrical energy intensity in kilowatt hours (kWh_e) per m^2 , by type of building (school, office, residential, hospital, etc.)
- Annual heating energy intensity in kilowatt hours (kWh_t) per m^2 , by type of building
- Annual energy cost intensity in renminbi (RMB) per m^2 , by type of building

Case Studies

ENERGY STAR-certified New Homes, USA

http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager_intro

In the U.S., ENERGY STAR-qualified new homes are at least 15 percent more energy-efficient than homes built to the 2004 International Residential Code and must include additional energy-efficient features. Buildings are also eligible for ENERGY STAR certification if their gross floor area designations meet specified rules, if building operations meet thresholds for key operating characteristics, and the building has at least 11 full consecutive calendar months of energy data for all active meters. ENERGY STAR buildings represented more than 12 percent of the average U.S. new home market in 2006. The ENERGY

STAR program's success has been linked to support from numerous financial programs offered by states, municipalities, and utilities to reduce the cost of ENERGY STAR homes and to promote the perception that ENERGY STAR-rated homes have higher market value. ENERGY STAR buildings typically use 35% less energy than average buildings and cost US\$0.50 (3.16 RMB)³¹ less per square foot to operate. ENERGY STAR-certified homes are estimated to save U.S. homeowners more than a total of US\$350 million (2,208 million RMB) each year in utility bills.

Ministry of Housing and Urban-Rural Development Building Energy Efficiency Labeling Program, China

http://china.lbl.gov/publications/GBPN_Full_report

China's Ministry of Housing and Urban-Rural Development (MOHURD) established a national building energy-efficiency labeling (BEEL) program in 2008. BEEL is voluntary for residential and most non-residential buildings but mandatory for four types of buildings: (1) new government-owned office buildings or commercial buildings larger than 20,000 m², (2) existing government office buildings and large commercial buildings applying for government retrofit subsidies, (3) state or provincial energy-efficiency demonstration buildings, and (4) buildings applying for the Chinese Green Building Energy Labeling program. The BEEL rating score has a maximum of 100 points and is based on heating, ventilation, and air-conditioning (HVAC) as well as lighting system efficiency, compliance with mandatory standards, and optional building energy-efficiency features. The label gives a theoretical rating based on simulation results and a measured rating based on continuously measured operational energy use after occupancy. Pilot projects (62 residential and 54 commercial) are being conducted in 20 provinces and cities. Of the 116 total projects that applied to BEEL in 2011, only 82 received the label. The majority of BEEL projects received 1 star (35 projects) or 2 stars (34 projects); only 13 projects received the highest rating of 3 stars.

Commercial Building Disclosure, Australia

<http://www.cbd.gov.au/#>

Commercial Building Disclosure (CBD) is a national program managed by the Australian Government Department of Climate Change and Energy Efficiency. It was developed by the national, state, and territory governments to improve the energy efficiency of Australia's large office buildings. Under the Building Energy Efficiency Disclosure Act 2010, an up-to-date Building Energy Efficiency Certificate (BEEC) must be disclosed to prospective buyers and tenants in most cases when an office space of 2,000 m² or larger is offered for sale, lease, or sublease. The BEEC consists of an energy-efficiency star rating for the building, an assessment of tenant lighting, and general energy-efficiency guidance.

³¹ World Bank official exchange rate of 2012: 1 USD = 6.31 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

Attributes

- Carbon Savings Potential
Medium
- First Cost to Government
Medium
- Speed of Implementation
1-3 year
- Co-Benefits
Reduced carbon emissions, improved air quality, improved comfort, increased employment opportunities, financial savings, higher market value

Tools and Guidance

Saheb, Y., E. Levina. 2012. *Building energy efficiency policies: codes, labels and incentive schemes*. International Energy Agency. February.

<http://www.iea.org/media/workshops/2012/buildingsrussia/Saheb2.pdf>.

North America Energy Working Group. *North American energy efficiency standards and labeling*.

http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/naewg_report.pdf.

China Academy of Building Research. 2011. *Building energy efficiency evaluation and labeling technologies in China*. May.

http://www1.eere.energy.gov/office_eere/pdfs/session_1_buildings_track_cao_yong_en.pdf.

B14: Mandatory Building Energy-Efficiency Audit and Retrofits

Description

An energy audit and retrofit program can focus on energy-efficiency retrofits and upgrades in municipally owned and operated buildings. Energy audits identify areas where efficiency improvement are needed, helping to determine how to allocate retrofit budgets. Energy audit options include: visual inspection of the building and analysis of historic energy usage data; a comprehensive standard audit; or computer simulation for complicated systems, structures, or facilities. Potential retrofits for municipal buildings include (but are not limited to) installation of: high-efficiency lighting; ENERGY STAR appliances and equipment; heating, ventilation, and air conditioning (HVAC) upgrades; improved insulation and window shading; measures to eliminate air leaks; and automated systems such as occupancy sensors. Post-retrofit savings on monthly utility bills often offset the up-front costs of the energy audit and retrofits within a short time.

Implementation Strategies and Challenges

Implementation Step	Description
Identify possible energy-efficiency opportunities	Using results from a benchmarking program or data collected on municipal buildings, the agency identifies possible energy-efficiency improvements (e.g., in lighting, air conditioning, heating, appliances, etc.) in municipal buildings.
Perform detailed energy audits	Agency representatives or auditors walk through building(s) to identify specific energy-efficiency opportunities and perform comprehensive energy audits or computer simulations as needed.
Set budget and requirements	Based on energy audit findings, the agency allocates funds for energy-efficiency upgrades. Combining upgrades with other necessary building renovations provides for efficient use of limited financing. Alternatively, the agency can contract with an energy service company (ESCO) to pay the first cost of the upgrades and share in the savings from the retrofits.
Design retrofits / upgrades	Considering the benchmarking data, the agency performs detailed energy audits, identifies budgetary constraints, designs specific retrofits, and carries out retrofits for each building.
Hire contractor to implement retrofits	Agency prepares a request for proposal for mechanical or electrical contractors to bid on the retrofit projects.

	Alternatively, agency prepares a request for proposal and awards an energy service contract to an ESCO. The ESCO guarantees energy savings, puts forward the initial investment, and shares future savings with the municipality.
Verify retrofit and performance	Agency verifies that the project has been constructed according to specifications in the energy-efficiency retrofit request for proposal and continues to collect electricity and heating bills for each retrofitted building and compares to historical data to verify performance of retrofits.

Implementation Challenges: lack of funding for audits and retrofits, lack of availability of historical energy usage data, lack of technical capacity for conducting energy audits, coordination challenges between building operators and program managers

Monitoring Metrics

Some suggested measures for this recommendation are:

- Number of projects completed per year
- Number of projects currently being carried out
- Number of energy audits completed and average energy savings identified per building
- Number of retrofit measures completed per building
- Number of buildings retrofitted
- Average actual energy savings per building
- Average payback period for retrofit measures
- Annual electrical energy consumption on a per-square-meter basis (kWh_e/m^2) for all municipal or residential buildings in the city, as a benchmark for comparison to post-retrofit consumption
- Annual heating energy consumption on a per-square-meter basis (kWh_h/m^2) for all municipal or residential buildings in the city, as a benchmark for comparison to post-retrofit consumption
- Energy cost on a per-square-meter basis (\$US or Renminbi/ m^2) for all municipal residential buildings, as a benchmark for comparison to post-retrofit consumption

Case Studies

New York City Energy Audits and Retrofits of City Buildings, USA

http://www.c40cities.org/c40cities/new-york/city_case_studies/new-york-city-government-leading-by-example

New York City's energy audit and retrofit program takes advantage of the significant opportunity for energy savings from retrofitting the 4,000 buildings that the city owns and operates, which are, on average, 60 years old. Established in 2007, the program is expected to continue until 2017 and to contribute 45% to the city's goal of reducing municipal greenhouse gas emissions by 30% in 2017. The program targets all of the city's existing buildings larger than 50,000 square feet. Energy audits assess electrical, HVAC, and building envelope systems and calculate annual energy savings, implementation costs, and simple payback for each potential retrofit measure. The city decides which retrofit measures to implement based on the energy audit. A total of 142 energy-efficiency retrofits had been completed, and 99 additional projects were in design or construction, as of spring 2012.

Green Building Retrofit Ordinance, Los Angeles, California, USA

http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA67R

In April 2009, the Los Angeles City Council approved the Green Building Retrofit Ordinance (Ordinance 180636) for energy-efficiency upgrades to the city's public buildings. The ordinance calls for retrofitting all city-owned buildings larger than 7,500 square feet or built before 1978; the retrofit target is Leadership in Energy and Environmental Design (LEED) Silver or higher certification, subject to the availability of state or federal funds. The ordinance requires that at least half of the buildings retrofitted be located in high-poverty and high-unemployment areas and, to the extent feasible, that all construction be performed by local residents. Initiatives resulting from this ordinance are expected to save the city US\$6 million (40.98 million RMB)³² in energy costs.

Audit and Retrofit City Buildings, Toledo, Ohio, USA

<http://www.ci.toledo.oh.us/Home/News/tabid/393/articleType/ArticleView/articleId/146/Default.aspx>

Since 2011, the City of Toledo and the Toledo-Lucas County Port Authority have conducted energy audits of 40 city-owned facilities, including 19 fire and 3 police buildings, community and senior centers, and key utility and transportation facilities. Eligible facilities will be retrofitted with high-efficiency lighting, heating, and cooling systems; and improved roofing and windows to reduce energy consumption and costs. Total project costs are estimated at US\$5.8 million (37.5 million RMB)³³ over 15 years, with a total reduction in energy costs of approximately US\$8.4 million (54.3 million RMB).

³² World Bank official exchange rate of 2009: 1 USD = 6.83 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

³³ World Bank official exchange rate of 2011: 1 USD = 6.46 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

Attributes

- Carbon Savings Potential
Medium
- First Cost to Government
Medium
- Speed of Implementation
1 - 3 years
- Co-Benefits
Reduced carbon emissions, improved air quality, improved comfort and worker productivity, enhanced public health and safety, increased employment opportunities, financial savings

Tools and Guidance

City of New York. 2015. *NYC Mayor's Office of Sustainable: Local Law 87: Energy Audits & Retro-Commissioning*. <http://www.nyc.gov/html/gbee/html/plan/ll87.shtml>

European Commission. 2006. *EU LOCAL ENERGY ACTION Good practices 2005*. <http://www.managenergy.net/download/gp2005.pdf>.

B15: Reach Standards and MEPS for Efficient Appliances and Equipment

Description

Minimum energy performance standards (MEPS) set mandatory minimum energy-efficiency requirements for appliances and equipment. MEPS push overall market efficiency upward by eliminating the production, import, and sale of equipment that is less energy-efficient than the standards. MEPS also help address market barriers to efficient equipment purchases, such as imperfect information and split incentives. Since their introduction during the 1970s, MEPS for major energy-consuming products have been adopted by more than 24 countries, including the United States, Canada, the European Union, Australia, and Korea.

The structure and content of MEPS vary by country but typically include the following components:

- Product-specific definitions and classifications
- Energy-efficiency metrics or energy consumption criteria (e.g., kilowatt hours [kWh] of consumption per year, power consumption, or energy-efficiency ratios)
- Standardized test procedures for measuring a product's energy performance

MEPS are usually developed by the national government through techno-economic analyses and in consultation with stakeholders (e.g., industry, manufacturers, consumer groups) to prevent having a patchwork of different local MEPS for the same product. However, local regions can adopt more stringent standards or new standards for products not yet covered by national MEPS, as local and state governments in Australia and the U.S. have done, with the goal of pushing additional or more efficient products onto the local market. These standards adopted by local regions can often lead to adoption of new or more stringent national standards. Some countries with national standards discourage the adoption of more stringent local standards because of concerns over trade barriers while others, such as Australia, encourage it.

Implementation Strategies and Challenges

Implementation Step	Description
Designate local authority for program	The relevant agency needs to designate a department or team responsible for setting and managing the local appliance standards program.
Define the products covered and their energy efficiency, applicability of energy efficiency standards, and cost effectiveness	The local government targets products for standards based on total energy-saving potential, technical feasibility, and economic attractiveness.
Assess overall benefits and costs	In addition to assessing the economics of individual technologies, the local government should assess overall benefits and costs. Benefits can include energy savings, energy bill reductions, electric system reliability improvements, future energy market price reductions, and air pollutant and greenhouse gas emission prevention. Costs can include product purchase costs, manufacturing costs, and program administration costs.

Find available test methods	Test methods are necessary to set efficiency levels for appliance standards. Test methods might have been established by national agencies such as the China National Institute of Standardization (CNIS) or by industry associations representing companies that make the products of interest.
Measure, monitor, and verify	Manufacturers submit product test documents (from third-party laboratories or supervised manufacture testing laboratories) verifying that their products meet the local efficiency standards. Manufacturers must also agree to participate in on-shelf verification if the local government deems it necessary.
Establish inspection and enforcement procedures	The local government establishes inspection and enforcement procedures that delineate the responsibilities of stakeholders, including the government itself, accreditation bodies, certification bodies, manufacturers, testing laboratories, etc.
Evaluate program impacts	The local government should evaluate the program impacts, adapt the program to changing circumstances, and demonstrate to funding agencies and the public that the expected benefits are being achieved.

Implementation Challenges: lack of technical capacity for developing local appliance standards, lack of jurisdictional authority to develop and enforce local standards, lack of funding for implementing and enforcing standards, resistance from industry and other stakeholders to more stringent standards

Monitoring Metrics

Some suggested measures for this recommendation are:

- Annual sales and stocks of appliances (number of units)
- Additional energy savings from the local standard relative to existing national standard (kWh)
- Rate of compliance with standard
- Change in greenhouse gas emissions after standard implemented
- Fuel savings from standard

Case Studies

California Appliance Efficiency Standards, USA

http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA48R&re=0&ee=1

In 1974, California was the first U.S. state to establish MEPS for appliances and equipment and has since then adopted MEPS for more than 50 products, many of the state's MEPS have subsequently been adopted as federal standards. For example, California adopted state MEPS for air conditioners, heat pumps, refrigerators and freezers, hot water heaters, and clothes dryers in the late 1970s; federal

standards were not adopted for these appliances until the 1990s. California's MEPS program has been credited with reducing peak electric demand by 2,000 megawatts (MW) or 5% of the state's total peak load. Today, California's MEPS program includes some of the most stringent U.S. standards and continues to lead the nation by adopting additional new efficiency standards for unregulated products. By 2010, the appliance efficiency standards that were in place in California as of 2002 are estimated to have reduced electricity demand by 2,485 gigawatt hours (GWh) and natural gas consumption by 20.9 cubic feet, equivalent to cumulative net savings of 12.79 billion Renminbi (RMB). California's current appliance efficiency regulations were adopted in 2008 and include 23 categories of appliances, both federally regulated and non-federally regulated products. Products covered in the state MEPS but not the federal MEPS include metal halide lamp fixtures and commercial cooking appliances and televisions. California is also in the process of developing the first U.S. MEPS for battery charger systems, with adoption scheduled for 2013 through 2017.

Attributes

- Carbon Savings Potential
High
- First Cost to Government
Low
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced carbon emissions, improved air quality, enhanced public health and safety, fuel savings

Tools and Guidance

Collaborative Labeling and Appliance Standards Program (CLASP). Resources and tools.

<http://www.clasponline.org/ResourcesTools>.

Wiel, S., J. McMahon. 2005. *Energy-efficiency labels and standards: a guidebook for appliances, equipment, and lighting*. Collaborative Labeling and Appliance Standards Program (CLASP).

http://www.clasponline.org/ResourcesTools/Resources/StandardsLabelingResourceLibrary/2005/~media/Files/SLDocuments/2005_SLGuidebook/English/SLGuidebook_eng_1_FullGuidebook.pdf.

China Energy Group, Lawrence Berkeley National Laboratory. *Appliance standards and labeling: appliance efficiency programs in China*. Accessed at 2012. <http://china.lbl.gov/research/appliance-standards-and-labeling>.

B16: Building Workforce Training

Description

Workforce training has emerged as a vital component in the successful implementation of energy-efficiency and clean energy in all sectors. Training is particularly important in the building sector where a well-trained workforce is crucial to energy efficiency audits, retrofits, installations of renewable building applications, and design and operation of efficient and green commercial and institutional buildings, which have increasingly sophisticated controls. In the U.S., the Department of Energy provides workforce development and educational opportunities for critical workforce skills to innovate, produce, install, maintain, and service advanced building energy technologies. In addition, local workforce training programs, such as California's Clean Energy Workforce Training Program and the New York State Energy Research and Development Authority's Energy Education and Workforce Development help meet the increasing workforce demands of a green economy. A workforce development program for the building sector helps create trainings, workshops, and curricula for energy auditors; insulation and weatherization technicians; heating, ventilation, and air conditioning (HVAC) technicians and installers; solar photovoltaic (PV) and solar water heating installers; and state energy and/or environmental staff. The program might also involve local governments working with established academic institutions to integrate workforce training into existing curricula and programs and tailoring programs for low-income workers or at-risk youth populations.

Implementation Strategies and Challenges

Implementation Activity	Description
Identify gaps between demand and supply	Program team examines current and future projections of business and labor market status to determine specific skill gaps in the locality.
Create partnerships	Team facilitates partnerships among workforce development entities such as state and local agencies, local career centers, community colleges, vocational high schools, and related non-governmental organizations.
Implement training program	Relevant information and training materials are provided on the program website. Applicants can register on line and then take a training course, which requires a certification examination for completion. If the participant successfully passes the examination, he/she is recognized as a certified worker by the institution offering the course.
Evaluate the program	The team evaluates the training program against its original goals and objectives. Ongoing evaluations throughout the program provide information needed to adapt the program and plan future activities to achieve the desired results.

Implementation Challenges can include: difficulty in engaging small to medium-sized firms; need for longer-term, broad education training rather than the short-term training offered by most workforce development programs; changing market conditions that make it difficult to identify gaps; lack of funding and resources to support workforce development programs; inability to coordinate and build partnerships.

Monitoring Metrics

Some suggested measures for workforce development are:

- Number of participants
- Number of website downloads
- Annual number of workers certified, by specific skill
- Program costs
- Jobs created

Case Studies

Better Buildings Neighborhood Program, Kansas City, Missouri, USA

http://www1.eere.energy.gov/buildings/betterbuildings/neighborhoods/kansas_city_profile.html

As one of the country's most economically challenged areas, Kansas City received US\$20 million (126.2 million renminbi [RMB])³⁴ in seed funding from the U.S. Department of Energy's Better Buildings Neighborhood Program to promote energy-efficiency and workforce development and training programs. As part of the program, EnergyWorks KC is creating new job opportunities where they are needed most, by increasing demand for upgrades and training a workforce to adequately meet that demand. For example, the Metropolitan Energy Center provides Building Performance Institute certification training to energy-efficiency professionals. Kansas City also provided training to approximately 45 energy-efficiency contractors, with a focus on marketing and sales to improve their business models.

Free Training Program in Green Building Technology, San Diego, California, USA

<http://www.sdce.edu/organization/news/free-training-program-green-building-technology>

The City of San Diego provides local residents access to a free training program in green building technology through the dedicated Sustainable Training and Resource Center. This facility includes a weatherization simulation used for energy auditing with high-tech infrared monitors; insulation demonstrations and applications; solar panel installation and maintenance; classroom facilities with a "tell-tale" pressure house to demonstrate energy savings and building envelope efficiencies; and a mobile weatherization lab, which takes training off site to any location in Southern California. A five-

³⁴ World Bank official 2012 exchange rate: 1 USD = 6.31 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

week program is designed to prepare students for entry-level work in the field or to enroll in further specialized training for HVAC mechanics, technicians, or installers; building performance or retrofit specialists; building control system technicians; energy auditors or home energy raters; and solar PV installers. The program is intended to help displaced workers, new workforce entrants, military veterans, and older out-of-school youths. Funding for this effort, totaling US\$1.6 million (10.1 million RMB) is from the American Recovery and Reinvestment Act, grants from the state Energy Program, Workforce Investment Act, and state Energy Sector Partnership. An additional US\$700,000 (4.42 million RMB) has been leveraged from contributing partners.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
<1 year
- Co-Benefits
Reduced carbon emissions, improved air quality, increased employment opportunities, fuel savings, improved economic productivity

Tools and Guidance

U.S. Department of Energy. Energy education and workforce development. Available at:
http://www1.eere.energy.gov/education/other_training.html

U.S. Department of Energy. Commercial building workforce development and training. Available at:
<http://www1.eere.energy.gov/buildings/commercial/workforce.html>.

Goldman, C.A., J.S. Peters, N. Albers, E. Stuart, M.C. Fuller. 2010. Energy efficiency services sector: workforce education and training needs. Lawrence Berkeley National Laboratory. Available at:
<http://eetd.lbl.gov/ea/EMP/reports/lbnl-3163e.pdf>.

B17: Public education campaigns on building energy efficiency and conservation

Description

Local governments can influence only a portion building energy usage through direct policy measures such as retrofitting public buildings and adopting stringent local energy-efficiency standards. To maximize energy conservation, it is necessary to also change the behavior of residents and business owners so that they become more energy conscious, implement efficiency measures, and conserve whenever possible. Thus, to significantly reduce local energy use, governments need to develop communication strategies, public education and citizen engagement campaigns, and sources of public information on energy efficiency and partner with stakeholders and the broader community to disseminate this information. These efforts are essential to making the most of limited resources and providing guidance that will reach community members and promote substantive change. Public education and awareness campaigns can encourage energy savings and conservation in buildings by highlighting the financial savings and the benefits to the environment that result from reduced energy use. Government campaigns can promote energy efficiency by demonstrating that longer-term financial gains can offset the initial costs of efficient measures and practices and are effective as part of the launch of new financial incentives, resources, tools, and services for energy efficiency or conservation.

Implementation Strategies & Challenges

Implementation Step	Description
Identify opportunities for awareness programs	The team identifies activities that have the best potential for achieving building energy savings and establishes a baseline for energy-efficiency awareness.
Establish energy- efficiency awareness program objectives	The team specifies energy savings targets for an awareness program or adopts less tangible objectives such as changing the awareness and behavior of building occupants.
Develop a communication plan	The team identifies existing lines of communication, target audiences, anticipated challenges, communication messages, and tools.
Implement the energy-efficiency awareness program	The team works with communication partners to disseminate the awareness program.
Evaluate the program	The team evaluates the awareness program against original goals, objectives, and baseline to determine whether it is effective. Ongoing evaluations throughout the campaign provide information needed to adapt the program and plan future activities to achieve desired results.

Implementation Challenges: lack of funding and resources to support campaigns, lack of ability to build effective partnerships and communication strategies, lack of public interest/response/participation in campaigns

Monitoring Metrics

Some suggested measures for this recommendation are:

- Number of program participants
- Number of website views and downloads
- Costs of implementing public education campaigns

Case Studies

“Power2” Campaign, Charlotte, North Carolina USA

<http://www.power2charlotte.com/news/power-2-press-release.aspx>

The City of Charlotte's "Power2" Campaign offers resources and services to Charlotte residents, business owners, and the local government about energy efficiency and sustainability, emphasizing that saving energy saves money and reduces environmental harm. The citywide program provides information on home energy audits and energy meters, encourages the use of clean renewable energy, and offers information to enable residents to make decisions that reduce overall energy consumption in the community.

Consumer Education Program for Residential Energy Efficiency, New York, USA

<http://www.human.cornell.edu/che/DEA/outreach/consumer-education-program-for-residential-energy-efficiency.cfm>

The Consumer Education Program for Residential Energy Efficiency is a joint effort of the Department of Design and Environmental Analysis at Cornell University and the New York State Energy Research and Development Authority. The program goals are to increase consumer awareness of the importance of energy efficiency and the multiple benefits of energy-efficiency and building practices; promote specific programs that encourage the purchase and installation of energy-efficient products and incorporation of comprehensive building practices; spur consumer demand for energy efficiency through education and incentives; and develop and support a midstream market that brings these products and practices to customers.

“Saving Money by Saving Energy,” U.S. Department of Energy

<http://energy.gov/energysaver/articles/saving-money-saving-energy-goes-national>

The U.S. Department of Energy and Ad Council's national education campaign to help consumers save money on utility bills included a series of public service announcements directing homeowners to the Energy Saver website to find tools and information to make their homes more efficient. Energy Saver Tips on the website offer practical ideas for reducing household energy consumption, such as using a programmable thermostat to reduce heating and cooling bills or upgrading light bulbs to save money. In addition to the tips, the campaign included an "energy savings IQ" quiz, a photo gallery on Facebook, and videos posted on YouTube that encourage consumers to save money by saving energy.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
<1 year
- Co-Benefits
Reduced carbon emissions, improved air quality, fuel savings

Tools and Guidance

U.S. Department of Energy. Home energy efficiency. Available at: <http://energy.gov/public-services/homes>.

U.S. Department of Energy. Energy Savers: tips on saving money & energy at home. Available at: http://energy.gov/sites/prod/files/energy_savers.pdf.

Industry Policy Recommendations

- I01: Benchmarking
- I02: Energy Audit / Assessments
- I03: Industrial Energy Plan
- I04: Stretch Targets for Industry
- I05: Subsidies and Rewards for Industrial Energy Efficiency
- I06: Industrial Energy Efficiency Loans and Innovative Funds
- I07: Tax Relief
- I08: Energy or CO₂ Tax
- I09: Industrial Equipment and Product Standards
- I10: Differential Electricity Pricing for Industry
- I11: Energy Management Standards
- I12: Energy Manager Training
- I13: Recycling Economy and By-product Synergy Activities
- I14: Low-carbon Industrial Parks
- I15: Fuel-switching

I01: Benchmarking

Description

Benchmarking is a means to compare the energy performance of a company or plant to that of other similar facilities producing similar products. Benchmarking can compare plants, processes, or systems. Four types of benchmarking are commonly used for energy-efficiency benchmarking:

- **Past performance** benchmarking (internal benchmarking) compares the enterprise's current energy efficiency performance to its historical performance. This type of benchmarking can be used to track the improvements of energy-efficiency within the same enterprise.
- **Peer-to-peer** benchmarking compares the level of energy- efficiency among peers, i.e., similar industrial plants in the same sector. This type of benchmarking can be used to identifying the energy-saving potential in an individual facility or among the peer group as a whole as well as to identify the highest energy-efficiency level among the peer group.
- **Standards** benchmarking refers to comparing the energy-efficiency level of the enterprise to national or sub-national minimum energy performance standards.
- **Best practice** benchmarking compares the energy efficiency of the assessed enterprises to a best practice benchmark, which can be a domestic or international best practice. This type of benchmarking identifies the potential for energy efficiency improvement if the assessed enterprise reaches the national or international best practice level.

After benchmarking, reports are prepared by the government agency in which enterprise names are not revealed but results are disseminated so enterprises can see how they compare.

Benchmarking is usually used as a first step to provide a rough understanding of energy-savings and emission reductions potentials. Additional energy-savings and emission reductions can be achieved when benchmarking is coupled with other key industrial energy efficiency policies, such as energy audits (see "Energy Audit / Assessments"), stretch targets (see "Stretch Targets for Industry"), and fiscal incentives (see "Subsidies and Rewards for Industrial Energy Efficiency", "Industrial Energy Efficiency Loans and Innovative Funds", and "Tax Relief"). Although Industrial Benchmarking programs are often administered at the national level, local governments can play a role by incentivizing or requiring the use of benchmarking within their jurisdiction. Expanding implementation can help provide local enterprises with more information and accelerate industrial energy and carbon savings.

Implementation Strategies and Challenges

Implementation Activity	Description
Identify implementing organization	The local government designates an existing governmental agency, a local research institution, or a third party to implement the benchmarking program.
Establish the benchmarking program design	The designated implementing organization determines the type(s) of benchmarking that will be conducted, determines the scope of the benchmarking program (which enterprises are included), establishes the procedures of the program (how enterprises report their data, how benchmarking results are disseminated), establishes the benchmarking program plans and targets, sets program milestones, and establishes program monitoring requirements.
Provide technical assistance and training	The implementing organization provides technical assistance and training on benchmarking methodologies and tools for enterprise energy managers.
Provide financial support	The responsible implementing organization can provide financial support to enterprises for undertaking the data collection activities needed to participate in the benchmarking program.
Conduct benchmarking	Following the benchmarking methodologies and protocols, enterprises collect data and submit it to the responsible implementing organization.
Information dissemination	The responsible implementing organization prepares benchmarking reports and disseminates them to participating enterprises.
Implement, monitor, and evaluate	The implementing organization will monitor and evaluate the year-on-year trends in enterprise energy efficiency that are shown by the benchmarking reports. The implementing organization will monitor the program results, evaluating its effects, and publicizing the information obtained through benchmarking while maintaining the confidentiality of individual enterprises.

Implementation challenges could include inexperience with benchmarking program design and implementation, lack of data or poor quality data at the enterprise level, lack of standardized methodologies for benchmarking, and lack of reporting, monitoring, and evaluating systems for the benchmarking program. More general, long-term challenges for energy efficiency benchmarking include how to incorporate benchmarking into the enterprise's energy management practices in order to make benchmarking a dynamic and continuous improvement process.

Monitoring Metrics

Monitoring metrics for a benchmarking program include:

- Number of participating enterprises

- Number of benchmarking reports issued annually
- Documented annual improvements in enterprise energy efficiency and resulting energy savings and CO₂ emission reductions

Case Studies

Industrial Energy Efficiency Network (IEEN), Norway

In the 1990s, Norway's Industrial Energy Efficiency Network (IEEN) developed an extensive benchmarking program. The IEEN provided technical and financial support for companies to undertake energy management activities and assess their energy-efficiency potential through benchmarking (Modig, 2006). The IEEN developed a web-based benchmarking system that allowed members to extract information about their own energy performance in relation to other plants within the same industrial sector. Every year industry network members provided data via the internet. Participating industries included: aluminum, bakeries, breweries, fishing, meat, dairy, grain-drying, fish meal, foundry, pulp and paper, timber and sawmill, and laundries and dry cleaners. The program was carried out in two steps. The first step focused on energy management activities including establishment of energy policy, information, education and training, organization of tasks, and adequate monitoring systems for energy and water consumption. The direct cost for the work involved was refunded by maximum 90% of the typical cost of around €3750 (38,663 RMB).³⁵ An additional €12,500 (128,875 RMB) could be granted for necessary hardware and software for establishing an efficient energy monitoring system. Second, based on the initial energy analysis, it was possible to take one further step and undertake an in-depth analysis of possible and profitable investments for energy conservation. It was then possible to get a financial support covering up to 50% of the consultancy and other costs. The maximum amount for this activity was limited to €25,000 (257,750 RMB) for one company.

Energy Efficiency Benchmarking Covenant, Netherlands

<http://www.benchmarking-energie.nl/>

In 1999, the Dutch government started the Energy Efficiency Benchmarking Covenant with industry. Participating large energy-intensive industrial companies agree to become one of the world's most efficient regions (regions defined as geographic areas with a production capacity similar to the Netherlands) or to be among the top 10% of the most energy-efficient plants in the world. In return, the government has promised not to impose any extra specific national measures governing energy conservation or CO₂ reduction on the participating companies. Six power generating companies and 97 industrial companies comprising a total of 232 facilities have signed the Benchmarking Covenant. These facilities have an aggregate energy consumption of 1,060 petajoules (PJ) (36 Mtce) and represent 94% of the industrial sector energy consumption and 100% of the electric sector energy consumption in the country. The benchmarks were established as follows:

³⁵ An average exchange rate in 2006 is used: 1 Euro = 10.31 RMB. See also: <http://www.oanda.com>.

(1) Most Efficient Region. In order to be compared to similar plants in one of the world's most efficient regions, regions outside of the Netherlands that are comparable with the Netherlands in terms of size and number of processing plants and which meet the best international standards are identified. The average energy efficiency of similar processing plants in these regions is then determined. The benchmark is the average energy efficiency in the region with the highest average.

(2) Top 10%. In order to be considered among the top 10% of the most energy-efficient plants in the world, the energy efficiency of comparable processing plants outside the Netherlands must be determined. These were ranked according to energy efficiency levels. The benchmark is the energy intensity of the best 10% of these processing plants.

The Energy Efficiency Benchmarking Covenant achieved 95 PJ (3 Mtce) of energy savings and 5.8 million tonnes of CO₂ emission reduction in the period 2000-2012.

ENERGY STAR for Industry Program, U.S. Environmental Protection Agency

http://www.energystar.gov/index.cfm?c=industry.bus_industry

The U.S. ENERGY STAR for Industry program is a voluntary U.S. government program that helps manufacturers to protect the environment through superior energy efficiency. The program has nearly 600 corporate members in a wide range of industries. These members can take advantage of energy management resources, networking opportunities, and sector-specific energy-efficiency guidebooks that include both process-specific and utility energy efficiency measures. In addition to these resources, the ENERGY STAR for Industry program has developed a benchmarking tool for measuring how efficiently a manufacturing plant uses energy compared to others in its industry in the U.S.

This industry-specific Energy Performance Indicator (EPI) tool ranks a plant based on its energy use and accounts for differences between the plants within an industry by normalizing for activities or factors that influence energy use. Plant and corporate energy managers input key operating conditions for a plant and receive a percentile score of their energy performance or efficiency. Inputs include energy use by energy type and annual production at the site. EPI benchmarking tools are currently available for automobile manufacturing plants, cement plants, container glass manufacturing plants, flat glass manufacturing plants, frozen fried potato processing plants, juice processing plants, petroleum refineries, pharmaceutical manufacturing plants, and wet corn milling plants. To date, 71 industrial facilities have used the EPI tool to qualify for the Energy Star label.

Under this program, a range of industries has achieved the goal of a 10% or greater improvement in energy efficiency within 5 years or less.

Attributes

- Carbon Savings Potential
Medium

The United Nations Industrial Development Organization (UNIDO) has found that implementation of Best Practice Technologies and Best Available Technologies identified

through energy efficiency benchmarking could potentially increase facility energy efficiency by 1.2% and 1.7% per year, respectively. Best Available Technologies are defined as [fill in definition] while Best Practice Technologies are defined as [fill in definition].

Overall, city-wide energy savings and emission reductions potentials from a benchmarking program depend on the size of the industrial sector of the city and the scope and scale of the benchmarking program. It is estimated that the energy-savings and emission reduction potential from an effective benchmarking program would be Medium, in the range of 0.5 Mtce to 1 Mtce.

- First Cost to Government

Low

Cost information on conducting benchmarking is limited in energy literature, as energy-efficiency benchmarking programs are often coupled with other energy-efficiency improvement activities, such as energy auditing and energy management programs. However, an energy-efficiency benchmarking program is typically recognized as a low cost policy for local cities and governments to implement, either through administrative mandates or through voluntary approaches.

- Speed of Implementation

<1 year

- Co-Benefits

Reduced carbon dioxide and other pollutant emissions, reduced water use and waste, improved air quality, enhanced public health, increased productivity, energy and cost savings for enterprises.

Tools and Guidance

U.S. Environmental Protection Agency. *ENERGY STAR Industrial Benchmarking Tools*.

<http://www.energystar.gov/index.cfm?c=industry.industrybenchmarkingtools>.

Lawrence Berkeley National Laboratory. *Benchmarking and Energy Saving Tool (BEST)*. <http://industrial-energy.lbl.gov/node/100>.

Natural Resources Canada. *Benchmarking Guides*. <http://oee.nrcan.gc.ca/industrial/technical-info/benchmarking/general/10678>.

UNIDO (United Nations Industrial Development Organization), 2010. *Global Industrial Energy Efficiency Benchmarking: an Energy Policy Tool*. Working Paper. November.
http://www.unido.org/fileadmin/user_media/Services/Energy_and_Climate_Change/Energy_Efficiency/Benchmarking_%20Energy_%20Policy_Tool.pdf

References

Modig, G., 2006. "Evaluation of the industrial energy efficiency network in Norway." *Intelligent Energy Europe*, EIE-2003-114. <http://www.aid-ee.org/documents/013IndustrialEnergyEfficiencyNetwork-Norway.PDF>.

I02: Energy Audits / Assessments

Description

Conducting an energy audit or assessment of an industrial enterprise involves collecting data on the major energy-consuming processes and equipment in a plant as well as documenting specific technologies used in the production process and identifying opportunities for energy efficiency improvement throughout the plant, typically presented in a written report. Standardized tools, informational materials, and other energy-efficiency products are often provided during the audit. Some audit programs, like the U.S. Department of Energy's Energy Savings Assessments program, provide a directory or network of accredited auditors.

Energy audits or assessments are sometimes coupled with benchmarking, as a way to quickly identify the energy-savings potentials before conduct a full energy assessment. For more information on benchmarking, please see policy "Benchmarking". To incentivize use of energy audits or assessments as well as adoption of recommended energy efficiency technologies and measures, fiscal incentives, such as fiscal rewards ("Subsidies and Rewards for Industrial Energy Efficiency"), energy efficiency loans and funds ("Industrial Energy Efficiency Loans and Innovative Funds"), or tax relief ("Tax Relief") can be provided. Other policies, such as a national or sub-national energy or CO₂ taxes ("Energy or CO₂ Taxes") or differential electricity pricing ("Differential Electricity Pricing for Industry") could also incentivize industrial plants to achieve higher savings through conducting energy audits and implementing the recommended energy-saving measures.

Implementation Strategies and Challenges

Implementation Activity	Description
Identify implementing organization	The local government designates an existing governmental agency, a local research institution, or a third party to implement the energy auditing program.
Establish the energy audit program design	The designated implementing organization determines the energy audit or assessment program design by identifying key elements of the program, including program scope (targeting sectors and industries), program duration (1 year or multiple year program), program budget (e.g., government funding for subsidies, technical assistance and training), and program requirements (e.g., types of energy auditing, required standards to use, required data reporting, and monitoring).
Identify qualified energy auditors	The designated implementing organization identifies qualified energy auditors through a certification or accreditation process, or hires qualified third-party energy auditors. A list of the qualified energy auditors can be publicized and available for industrial enterprises to contact.

	The auditor should consult plant personnel regarding the scope of the audit, seek information regarding areas of priority, discuss the planned audit methodology, and define the audit timeline.
Develop and provide standardized auditing methodologies and tools	The implementing organization can work with industrial associations, industrial companies, and research institutes to develop energy auditing standards, software tools, and data collection templates. Specific standards or tools can be developed for specific industrial sectors.
Provide training and technical assistance	The implementing organization can provide training and technical assistance related to conducting energy audits to energy auditors, energy managers at the industrial companies, or to the top management of the companies, through online or in-class training, guidebooks, information sheets, case studies, and other information dissemination channels.
Conduct energy audits/assessments	Energy audits are conducted in industrial plants, either using in-house energy engineers or third-party energy auditors that meet the qualifications of the program.
Develop a database of energy audit results	To better use the results of energy audits, the implementing organization can develop a database to collect, aggregate, and analyze the results of energy audits, including identified energy savings potentials, cost savings, recommended energy-saving measures, implementation rates, and realized energy and cost savings, by industrial sectors.
Announce awards and/or publicize case studies	The implementing organization can incentivize industrial companies to conduct energy audits and to implement energy-saving measures through awards or case studies to provide positive publicity to the top energy-saving enterprises.

Implementation challenges include a lack of financial support for energy audit programs, lack of standardized energy auditing/assessment standards, methodologies, software tools, or templates; lack of qualified energy auditors; lack of databases for aggregating and analyzing energy auditing results for policy decision purposes; lack of post-audit evaluations regarding implementing rates of recommended energy-saving measures.

Monitoring Metrics

Monitoring metrics for energy audits/assessments include:

- Number of industrial facilities that undertake energy audits/assessments per year
- Average estimated energy and cost savings per facility
- Average estimated energy audit costs per facility and per unit of energy saved
- Recommended energy-saving measures
- Implementation percentage of energy audit recommendations

Case Studies

Industrial Assessment Centers (IACs), U.S. Department of Energy

http://www1.eere.energy.gov/manufacturing/tech_deployment/iacs.html

The U.S. Department of Energy (DOE)'s Industrial Assessment Centers, located at 24 universities throughout the U.S., perform in-depth assessments of small- and medium-sized industrial facilities including a detailed evaluation of potential savings from energy efficiency improvements, waste minimization and pollution prevention, and productivity improvements (U.S. DOEa, n.d.). Each manufacturer typically identifies about \$55,000 (342,025 RMB) in potential annual savings on average. Nearly 16,000 IAC assessments were conducted between 1981 and 2013. Manufacturers are eligible to receive an IAC assessment if they meet these criteria: (1) facility is classified within Standard Industrial Codes (SIC) 20-39; (2) facility is located within than 150 miles of a participating IAC university; (3) facility's gross annual sales are below \$100 million (621.9 million RMB); (4) facility has fewer than 500 employees at the plant site; (5) facility's annual energy bills more than \$100,000 (621,861 RMB) and less than \$2.5 million (15.5 million RMB); and (6) facility does not have professional in-house staff to perform the energy assessment. Typical assessment reports include more than a dozen recommendations with average payback period of less than 2 years. Average annual savings for measures recommended by IACs exceeded \$240,000 (1.49 million RMB) per plant and range from \$50,000 (310,930 RMB) to \$3,000,000 (18.66 million RMB). Potential returns on investment for IAC audits from DOE are from \$10 (62.2 RMB) to \$20 (124.4 RMB) for each audit dollar. Each university receives \$200,000 (1.24 million RMB) to \$300,000 (1.87 million RMB) per year for up to 5 years to help university teams gain practical training on core energy management concepts through DOE's IAC program.

Save Energy Now, U.S. Department of Energy

http://www1.eere.energy.gov/manufacturing/tech_deployment/

In 2006, the U.S. DOE's Industrial Technologies Program initiated the Save Energy Now program that provides trained energy experts to perform Energy Savings Assessments at the most energy-intensive manufacturing facilities in the U.S. (U.S. DOEb, n.d.). The assessments targeted the largest energy-consuming manufacturing plants, consuming 1 trillion Btu or more annually in six industries (over 80% of

the assessments were in these industries): chemical manufacturing, paper manufacturing, primary metals, food, non-metallic mineral products, and fabricated metal products. The purpose of the assessments is to identify immediate opportunities to save energy and money, primarily by focusing energy-intensive systems such as process heating, steam, compressed air, fans, and pumps. In 2006, the Save Energy Now program completed 200 assessments at large manufacturing plants and found that the typical large plant can reduce its energy bill on average by over \$2.5 million (15.5 million RMB) per plant, for a total of \$500 million (3.11 billion RMB) in identified energy cost savings and over 4 million metric tons of CO₂ emissions reductions.

Comprehensive Industrial Energy Efficiency Program, San Diego, California, U.S.

<http://www.sdge.com/save-money/no-cost-audits/comprehensive-industrial-energy-efficiency-program>

The Comprehensive Industrial Energy Efficiency Program (CIEEP) of San Diego Gas and Electricity (SDG&E) offers its industrial customers a no-cost facility audit to identify their comprehensive energy efficiency solutions. Customers from the industrial sector include printing plants, plastic injection molding facilities, component fabrication facilities, lumber and paper mills, cement plants and quarries, metals processing, petroleum refineries, chemical industries, assembly plants, and water and wastewater treatment plants. Four sub-programs, including audits, calculated, deemed, and continuous energy improvement, comprise the core product and service offerings for the industrial sectors.

Energy Audit Program, France

In 1999, an energy audit program called “Aide à la décision” (Decision Making Support Scheme) was launched in France. This program covered both the industry and building sectors, except for individual single houses. There are two types of energy audits defined in the program, including simplified energy audits aimed at a wide evaluation through a quick assessment and detailed energy audits with comprehensive detail energy audits and feasibility studies. For the industrial sector, the annual goals of the program for the period of 2000-2006 were to conduct 600 pre-audits in enterprises with energy use less than 5,000 tonnes of oil equivalent (toe) per year (7,143 tce per year), and 400 general audits in industries with the energy use more than 5,000 toe/year (7,143 tce/year). The expected energy savings from the industrial sector was 58000 toe/year (82,857 tce/year). With these objectives, the annual budget allocation for industrial energy audits was €11.4 million Euros (96.2 million RMB).³⁶ Subsidies were given to industrial sectors in the program in the form of co-payments for energy auditing costs. These subsidies varied from 50% to 70% of the audit cost depending on the different types of energy audits. Subsidies or incentives were paid to the clients only after the energy auditors fulfilled the requirements of the audit specifications and the auditing reports were evaluated by the regional delegations of French Environment and Energy Management Agency (Despretz, 2002).

³⁶ Based on the historical exchange rate in 2002: <http://www.oanda.com/currency/historical-rates/>.

Energy Audit Program, Finland

Finland has had an active energy audit program since 1992. The program focuses on energy audits in several sectors, including buildings and processes in the service (both private and public³⁷) and industrial sectors, as well as energy-intensive process industry. Finland's Voluntary Agreement Scheme (VA Scheme), which covered around 85% of total industrial energy use and more than 50% of the building stock in the service sector, was launched in 1997. Because the VA Scheme required all participating enterprises and organizations to conduct energy audits, it was a key instrument for promoting the implementation of energy audits. After voluntarily signing agreements with the government, the enterprises agreed to reduce energy consumption and committed to conduct energy audits and implement suggested cost-effective energy-saving measures found in the audits.

The Finnish Ministry of Trade and Industry (MTI) was the Ministry in charge of energy-efficiency actions in the industrial and service sectors. MTI's Energy Department was administrator of the energy audit program, and supervised "large-scale energy audit projects with a total audit cost over 170,000 Euros" and "non-standard projects of pilot nature" (Väisänen and Reinikainen, 2002).

Subsidies were used as a main instrument to promote energy audits since 1992. Around 40% to 50% of energy audit costs were covered by subsidies. Once the VA Scheme was established, subsidies for power plants and district heating plants and networks were also available starting in 1998. The MTI in Finland provided 50% subsidies to industrial enterprises and municipalities that signed agreements with the MTI (Väisänen and Reinikainen, 2002). The Finnish government also granted a 10% subsidy for investments in energy-saving measures that were recommended in the energy audit reports.

Attributes

- Carbon Savings Potential
Medium

The energy savings potential of energy auditing programs is highly related to: 1) the potential of energy savings that is able to be identified through high-quality energy audits; 2) the implementation rate of recommended energy saving measures; 3) the number of energy audits that are conducted. Based on the average energy-savings potential and implementation rates as the audits conducted by the U.S. Industrial Assessment Centers, it is estimated that for a local city the annual energy-savings and emission reduction potential is medium, in the range of 0.5 Mtce to 1.0 Mtce.

- First Cost
Medium

The cost for local governments to implement industrial energy audits varies with the number of energy audits required. Using the U.S. Industrial Assessment Center's funding level as a

³⁷ Public service sector refers to municipalities and non-governmental organizations.

reference, the total cost for a local government is estimated to be medium, in the range of 10 million RMB to 30 million RMB.

- Speed of Implementation
1 -3 years
- Co-Benefits
Reduced carbon dioxide and other pollutant emissions, improved air quality, enhanced public health, increased productivity, energy and cost savings for enterprises.

Tools and Guidance

Hasanbeigi, A., L.Price, 2010. *Industrial Energy Audit Guidebook*. Lawrence Berkeley National Laboratory (LBNL-3991E). Berkeley, CA. <http://china.lbl.gov/publications/industrial-energy-audit-guidebook>.

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Despretz, H., 2002. *SAVE II Project Audit II: Country Report France*. http://www.motiva.fi/files/1921/CR_FR.pdf.

Väisänen, H., and E. Reinikainen, 2002. *SAVE II Project AUDIT II: Country Report Finland*. <http://www.motiva.fi/files/1945/CR-FIN.pdf>.

I03: Industrial Energy Plan

Description

An industrial energy plan outlines a region's or an enterprise's plan for improving industrial energy efficiency during a specified period. These plans are also called energy strategic plans or energy action plans. An energy strategic plan primarily sets an overall industrial energy-saving target, while an energy action plan provides the guidance for internal implementation of the activities that will be undertaken to reach the energy-saving target.

In general, an industrial energy plan should include a description of the region or enterprise with respect to its industrial energy consumption, a description of the energy-efficiency measures considered, a description of the planned energy-efficiency measures, a timeframe for implementation of the energy-efficiency measures, and expected results in terms of energy efficiency. Once the energy plan is drafted, an independent third party can be retained to review the plan and make suggestions for adjustments, if needed. If conditions change at the region or enterprise or if planned energy-efficiency projects change, the energy plan should be revised and reviewed. The energy plan also serves as a reference to evaluate progress on an annual basis.

Local governments or industrial companies can use an energy plan to stretch their energy-saving and emission reduction targets to achieve a higher degree of savings. For more information, please see policy "Stretch Targets for Industry" on stretch targets.

Implementation Strategies and Challenges

Implementation Activity	Description
Identify implementing organization	The local government designates an existing governmental agency, a local research institution, or a third party to implement the policy. For a regional energy plan, a leadership team is typically set up at the government level and made up of multiple city agencies that will play a role in plan development. For an enterprise energy plan, an industrial enterprise can also establish an internal team.
Establish the program	The designated organization has the authority and responsibility for establishing the program elements, direct the funding resources, and implement the program to achieve its targets.
Develop an industrial energy vision	A common vision is developed with all stakeholders (e.g. government, industrial enterprises and associations, planners and academic experts for a regional plan;

	appropriate enterprise management and staff for an enterprise plan) to ensure a unified effort. Identifying the top priorities for specific stakeholders can help develop a vision, as well as narrow the efforts that will be undertaken.
Develop an industrial energy baseline	For a regional energy plan, the stakeholders need to establish an energy baseline which includes all relevant sectors, serves as the starting point of all analysis, and identifies the largest energy users and potential program and policy targets. For an enterprise energy plan, the current level of energy use and output production, disaggregated to the extent possible by energy-consuming processes, must be established.
Develop specific energy goals	Clear energy action goals should be set with a timeline, based on the developed vision and baseline.
Design specific programs to achieve the energy goals	Specific programs or actions to achieve the energy goals should be established based on the cost-effectiveness of different programs and available resources.
Identify funding sources	Financial support needs to be secured for the programs or actions being proposed in the energy plan.
Initiate and undertake the plan	For a regional energy plan, the leadership team completes the plan which summarizes the vision and goals, consolidates the information gathered, identifies specific programs or actions and funding sources, and makes it publicly available. For an enterprise energy plan, the internal team completes the plan which summarizes the vision and goals, consolidates the information gathered, identifies specific programs or actions and funding sources, and distributes it as appropriate to enterprise management and staff.
Implementation, measurement, and verification	Energy action plan actions are implemented, measured, and verified to determine annual energy savings and the overall effectiveness of the plan.

Some possible challenges for implementing an industrial energy plan include: lack of financial support to undertake planned energy efficiency actions; lack of awareness of or underestimate of the industrial energy efficiency improvement potential; difficulties in monitoring, documenting and evaluating the implementation of energy efficiency programs.

Monitoring Metrics

Monitoring metrics for regional industrial energy plans include:

- Number of enterprises that adopt industrial energy plans

- Total expenditures for implementing industrial energy plans
- Annual energy savings realized after implementing industrial energy plans
- Annual reductions of carbon dioxide emissions and other pollutants after implementing industrial energy plans
- Annual reductions of water and raw material use after implementing industrial energy plans

Monitoring metrics for enterprise industrial energy plans include:

- Total expenditures for implementing industrial energy plans
- Annual energy savings realized after implementing industrial energy plans
- Annual reductions of carbon dioxide emissions and other pollutants after implementing industrial energy plans
- Annual reductions of water and raw material use after implementing industrial energy plans

Case Studies

Long Term Agreements (LTAs), Netherlands

<http://iepd.iipnetwork.org/policy/long-term-agreements-energy-efficiency>

The Long-Term Agreements (LTAs) are negotiated agreements aimed at promoting energy savings in industry that have been a key element of energy policy in The Netherlands since the early 1990s. The first agreements (LTA1) ended in 2000 and focused primarily on the efficiency of the production process for energy-intensive sectors. Starting in 2000, energy-intensive companies (energy consumption > 0.5 PJ/year, or > 17,060 tonnes of coal equivalent (tce) per year) were covered by the Benchmarking Covenant while less energy-intensive companies (<0.5 PJ, or <17,060 tce), medium-sized and small industrial companies fell under the 2nd generation LTA (both ran until 2012). In 2007, the 3rd generation agreements were launched, LTA3, which represents an expansion, intensification, and broadening of the LTA2 program and runs until 2020. The LTA2 and LTA3 programs added energy savings throughout the entire product chain. LTA2 and LTA3 targets of improving energy efficiency by 30% between 2005-2020 consist of an improvement by 20% within plant borders and 10% outside (e.g. by less material use or recycling, waste heat or renewables use/generation, or by making efficient products)

Each LTA participant is required to make an Energy Efficiency Plan and to implement all profitable measures (with payback periods of 5 years or less) from a technology list developed at the sector level. In return, the participating companies are largely exempt from the national energy and/or carbon tax and are automatically granted compliance with the energy-related provisions of their permits under the Environmental Management Act. In addition, no supplementary national policy related to energy conservation and CO₂ emission will be imposed on these companies. At the end of 2007, the LTA1 and LTA2 programs had realized an overall average energy efficiency improvement of more than 2% per year in the more than 900 participating companies from almost 30 sectors. A steadily increasing number of

participants have also adopted energy management in their operational management (93%). Since 2001, improvement of total energy efficiency has led to avoided CO₂ emissions of 6.9 MtCO₂. Annually, this is an average of almost 1 Mt CO₂ of avoided emissions.

California long term energy efficiency strategic plan, U.S.

http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf

The California Public Utilities Commission (CPUC) created a long-term strategic plan for California energy efficiency through 2020 and beyond. This comprehensive plan for 2009 to 2020 is the state's first integrated framework for goals and strategies for saving energy, covering government, utility, and private sector actions. Regarding industrial sectors, the goal is for energy intensity (per gross dollar of production value) to be reduced at least 25 percent by 2020 (CPUC, 2011). In addition, energy efficiency certification and benchmarking will become a standard industrial practice for businesses that are responsible for 80 percent of the state's industrial energy use. In order to meet these goals, the long term strategic plan also provided a specific implementation plan and timeline.

Texas Industries of the Future Chemical and Refining Sectors Strategic Plan, U.S.

http://texasiof.ces.utexas.edu/PDF/Documents_Presentations/Documents/Strategic%20Plan%202010-2020%20TIOF%20Rev2011.pdf

The industrial sector in Texas, especially chemical manufacturing and refining, is the most energy intensive of all U.S. states, accounting for 18% of the energy used in the U.S. From 2010 to 2020, the Texas Industries of the Future (IOF) program is committed to work with Texas chemical and refining sectors to facilitate progress towards energy intensity reduction goals set by the US DOE and the Energy Policy Act of 2005. The Texas Industries of the Future program has worked extensively with the chemical manufacturing and refining sectors and also with small to large manufactures from sectors such as food processing and semi-conductor manufacturing.

Strategies for improving energy efficiency and environmental performance and reduce cost in chemical and refining industries include: (1) develop a best practice check list, with a focus on sustaining energy efficiency at low utilization rates; (2) develop a focus area in waste heat, to include the development of evaluation tools, expertise development and feasibility analysis; (3) develop a focus area in cooling system optimization, to include assessment protocol development, assessments, and best practice documentation; (4) conduct a third technology showcase, as a component of other energy conferences; (5) offer/promote four training per year on Best Practices in energy systems, management, or technologies; (6) conduct at least two Texas Industrial Energy Management Forums annually; (7) pilot the national energy-efficiency certification program at 5 sites in Texas in 2008-2011; (8) network with manufacturing and business organizations in the state to promote energy efficiency tools and resources

to small and medium sized facilities; (9) organize an energy management session at the regional Process Technology Conference; (10) demonstrate Superior Energy Performance, the national energy-efficiency certification program, and ISO 50001 at five Texas plants (2011-2013); (11) facilitate communication with suppliers of specific energy system equipment, promote awareness and participation in NGO and government sponsored energy efficiency and environmental improvement awards, and conduct education on greenhouse gas issue.

The Texas IOF manual and calculator to help small and medium sized manufacturers assess energy savings opportunities is in use by the Texas Manufacturing Assistance Center, which reports identifying savings of \$660,000 (4.1 million RMB) at 9 facilities, with replication opportunity at another 13 sites. Best Practice workshops are estimated to have saved 1.791 Trillion BTUs (or 64,500 tce) as a result of attendees using the software and implementing energy saving projects back at their plants (Texas IOF Chemical and Refining Advisory Committee, 2011).

Attributes

- Carbon Savings Potential

Medium

The energy-savings and carbon dioxide emission reduction potentials of an industrial energy plan depend on the size of the local city's industrial sector, as well as the current energy efficiency levels of its enterprises. For a local city with moderate or low energy-efficiency in its industrial sectors, and with an ambitious energy-saving target, the potential of energy-savings and emission reductions are high.

- First Cost to Government

Low

The cost for government to merely make an industrial plan is considered low. It doesn't include the costs of other financial measures such as subsidies and tax refunds.

- Speed of Implementation

<1 year

- Co-Benefits

Reduced carbon dioxide and other pollutant emissions, improved air quality, enhanced public health, increased productivity, energy and cost savings for enterprises.

Tools and Guidance

Major Economies Forum on Energy and Climate. *Technology Action Plan: Industrial Sector Energy Efficiency*. December 2009.

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http://www1.eere.energy.gov/manufacturing/tech_deployment/ebulletin.html.

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http://www1.eere.energy.gov/manufacturing/tech_deployment/.

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http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf.

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http://texasiof.ces.utexas.edu/PDF/Documents_Presentations/Documents/Strategic%20Plan%202010-2020%20TIOF%20Rev2011.pdf.

I04: Stretch targets for Industry

Description

A “stretch target” is a target that is more difficult or more ambitious than an existing policy target or goal. It goes beyond the minimum or mandated targets. To achieve a stretch target, industrial companies may need to invent new strategies, new incentives, and new ways of achieving their targets (Behn, 2011). In the area of industrial energy efficiency, a stretch target can be a voluntarily announced energy saving or energy intensity target that goes beyond the mandatory government-issued target. Local governments can establish a stretch target for certain existing policies, to achieve a higher policy outcome, to generate greater energy savings, or to realize larger carbon dioxide emission reductions.

To meet the stretch targets, several policies or programs could be utilized, such as conducting energy-efficiency benchmarking (I01) and energy audits (I02), establishing industrial energy plans (I03), providing fiscal incentives through tax relief (I07) or formulating an energy or CO₂ tax (I08). Establishing a rigorous energy management standard (I11) and providing energy manager training could improve operational practices and help industrial facilities to continuously improve their energy efficiency levels.

Implementation Strategies and Challenges

Implementation Activity	Description
Identify implementing organizations	The local government designates an existing governmental agency, a local research institution, or a third party to establish the stretch target.
Establish an industrial energy use baseline	The designated implementing organization should establish a baseline of the current energy use in the targeted industrial sectors.
Assess the energy efficiency or CO ₂ emission reduction potential	In order to set stretch targets, the enterprises and the implementing organization need to assess the energy efficiency or CO ₂ emission reduction potentials of each sector and/or each enterprise
Set an stretch goal	Based on the baseline energy use, existing policy targets, and the energy efficiency or CO ₂ emission reduction potential, the implementing organization develops a stretch goal for targeted industrial enterprises or sectors. The stretch target could be a certain percentage higher than the existing targets, or it could be set at a specific energy-efficiency level.
Provide technical assistance	Local governments can provide additional technical assistance to industrial enterprises through information dissemination, trainings, and other tailored services to assist companies in achieving the stretch target.
Monitor and evaluate	It is important for enterprises and local governments to establish an energy measurement and reporting system to monitor and track actual annual energy, CO ₂ emissions, and/or cost savings results. Periodic

	evaluations on the progress toward the stretch target should be conducted to identify weaknesses, areas for future improvement, and good practices for dissemination.
Information dissemination	The implementing organization should document and disseminate best practices, case studies, and other experiences of industrial companies in reaching the stretch targets, and publicize good case examples.

Some implementing challenges could include difficulty of setting a proper stretch targets (local governments might underestimate or overestimate industrial energy saving potentials), lack of necessary technical assistance to adequately assist industrial companies in reaching the stretch targets (within the government funding levels), and lack of a data collecting system to collect and track the performance of industrial companies.

Monitoring Metrics

- Monitoring metrics for stretch targets include:
- Number of participating enterprises
- Number of enterprises that meet the stretch targets
- Percentage of enterprises exceeding an existing target
- Annual energy savings from achieving the stretch targets
- Annual CO₂ emissions reduced from achieving the stretch targets

Case Studies

Climate Change Agreements, UK

<https://www.gov.uk/government/policies/reducing-demand-for-energy-from-industry-businesses-and-the-public-sector--2/supporting-pages/climate-change-agreements-ccas>

In 2000, the UK Climate Change Agreement (CCA) program for energy-intensive industries was established. If industries meet their targets, they are given a 65% discount from the UK Climate Change Levy, which is an energy tax established by the UK government. The CCAs currently cover 54 sectors, representing approximately 90% of industrial emissions in the UK. Collectively, the enterprises in the program have continuously exceeded their negotiated targets. In the latest target period, from 2009 to 2010, For example, the target for the period 2009-2010 was 18 MtCO₂ per year but actual achieved savings were 28.5 MtCO₂ per year.

According to the British Beer & Pub Association (BBPA), large UK brewers achieved an energy efficiency savings of up 25%, against the target of 20% set out in their CCA, representing an abatement of 506,000 tCO₂ per year and £3 million (28.2 million RMB) annual savings for UK brewers in Climate Change Levy payments. The industry is on track to meet its highly ambitious target of a 67 per cent reduction in CO₂ emissions by 2020 from 1990 levels.

Utilities exceeding the Sixth Power Plan's goal, Oregon, U.S.

http://www.nwccouncil.org/news/press-releases/2012-09-12_efficiency_improvements_set_record/

According to the Northwest Power and Conservation Council, Oregon's utilities once again exceeded the Sixth Power Plan's goal for energy efficiency achievements with lower costs than estimated in the plan in 2011. The utilities have exceeded plan targets every year since 2005. The Sixth Power Plan's five year target for 2010-2014 is 1200 average megawatts. In 2011, the region achieved 277 average megawatts of conservation savings, exceeding the Council's target of 220 average megawatts by 26%. In addition, the levelized cost of the 2011 savings was around \$18/MWh (111.8 RMB/MWh). In 2012, the production efficiency program of Oregon's Energy Trust set a goal of saving 160 GWh of electricity and 1250 MWh of heat. The budgets for 2012 were \$19 million (118 million RMB) for electricity and \$2 million (12.4 million RMB) for gas respectively (Energy Trust of Oregon, 2012).

Dow Chemical Company reaches stretch goals for energy efficiency, U.S

<http://oldwww.wbcsd.org/DocRoot/Eb1qLUYYchKPCk9ZAoIF/Dow-energy-efficiency-full.pdf>

Dow Chemical Company is one of the world's largest industrial consumers of energy. In 2007 the company used nearly 850,000 barrels of oil equivalent (0.16 Mtce) each day to supply its energy and feedstock needs globally. The total fossil fuel bill came to approximately \$27 billion (167.8 billion RMB), accounting for nearly half of the company's operating costs. Between 1990 and 1994, Dow reduced its energy intensity (energy use per unit of product) by 20%. In 1995 Dow made a commitment to reduce energy intensity by a further 20% per unit of product by 2005. Dow exceeded its 2005 goal by achieving a 22% reduction in energy intensity. Over ten years it saved approximately 900 trillion Btus (32 million tonnes of coal equivalent). In 2005 Dow further set a target of reducing energy intensity by a 25% per pound of product by 2015.

27 Standards – Advanced Goals for Industrial Products in China

China has published 27 national standards for high energy-consuming industrial products, including sectors such as cement, iron and steel, and non-ferrous metals. These standards not only state the minimum energy performance standards for the products (in terms of the maximum energy use levels per unit of production), but also include advanced energy efficiency levels for industrial companies to further improve, based on advanced international or domestic practices. During 2007-2008, 22 national standards were issued and five more additional standards were published in 2010. During the 12th Five-Year Plan, China plans to add more standards under the "Hundred Energy Efficiency Standards" initiative.

Attributes

- Carbon Savings Potential
Medium

If stretch goals are met, higher energy savings or CO₂ emissions reductions will be realized than what is planned through the original targets. The energy savings or emissions reductions beyond

the targets will vary depending upon the stringency of the original target as well as the amount by which it is surpassed.

- First Cost to Government

Low

For local governments, the cost for setting up the stretch targets is relatively low. The only costs are those associated with obtaining an understanding of the potential energy saving or CO₂ emission reductions. This information can be obtained through plant-level energy audits (see Hasanbeigi and Price, 2010; U.S. EPA, n.d.; U.S. DOE, n.d.) or through sector potential studies.

- Speed of Implementation

1-3 years

- Co-Benefits

Reduced carbon dioxide and other pollutant emissions, improved energy efficiency, improved air quality, enhanced public health & safety, increased productivity, energy and cost savings for enterprises.

Tools and Guidance

Prindle, W. n.d. *Best Business Practices in Energy Efficiency*. Pew Center on Global Climate Change.”

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http://www.energystar.gov/index.cfm?c=industry.bus_industry_plant_energy_auditing.

I05: Subsidies and Rewards for Industrial Energy Efficiency

Description

Financial instruments to promote industrial energy efficiency include economic incentives (e.g. subsidies for energy audits or investments, soft loans) as well as fiscal measures (e.g. tax reductions). Financial incentives aim to encourage investment in energy-efficient equipment and processes by reducing investment costs, either directly through economic incentives or indirectly through fiscal incentives. One of the commonly-used economic incentives is to provide customers or enterprises subsidies or rewards for specified industrial energy efficiency actions in order to reduce investment costs. Subsidies or rewards are given to enterprises as a fixed amount, as a percentage of the investment (with a cap), or as a sum proportional to the amount saved. They may also be given to equipment producers for development and marketing.

Subsidies and rewards can be used to promote a number of industrial energy-efficiency programs, such as conducting energy benchmarking (“Benchmarking”), implementing the recommended measures from energy audits/assessments (“Energy Audit / Assessments”), meeting stretch targets (“Industrial Energy Plan”), and investing in energy-efficiency projects in low-carbon industrial parks (“Low-carbon Industrial Parks”).

Implementation Strategies and Challenges

Implementation Activity	Description
Identify implementing organizations	The local government entity with authority to provide financial subsidies or rewards to enterprises should be designated to implement the subsidy/reward program.
Establish the subsidy/reward program	The implementing organization identifies key elements for the subsidy/rewarding programs, including the subsidy budget, program duration, program scope, and procedures for allocating the subsidies.
Establish and publicize criteria	The implementing organization establishes and publicizes the criteria for application for subsidies or rewards to related eligible industrial energy-efficient equipment, technologies, and other energy-efficient projects.
Submit an application	Industrial companies submit an application, which indicates the energy efficient equipment and technology that will be used, or other energy-efficiency measures that will be adopted as retrofit projects, as well as estimated energy savings and investment costs, and the timeline of the project.
Review and confirm the application	The implementing organization reviews the application and confirms that the plans are feasible. The implementing organization works with participants to determine eligibility as well as how to optimize the

	energy efficiency of the project.
Sign an incentive agreement	After the selection and design of the recommended energy efficiency project is finalized, the responsible implementing organization signs an incentive agreement with the participant delineating the proposed project details, estimated incentive amounts, and terms and conditions.
Verify performance	Once the retrofit is complete, the applicant submits an integrated design analysis report, manufacturer's specifications, and equipment cut sheets, and incremental cost verification to the program administrator to verify that the completed project matches the design proposed in the agreement. The responsible implementing organization undertakes an on-site verification. Independent, third party reviewers can also be used at this stage.
Allocate the payment	After the verification of performance and other documents, the participant will receive the payment from the responsible implementing organization.

Some possible challenges to implement subsidies and rewards for industrial energy efficiency include difficulty of designing effective subsidies and rewards programs, possible free riders (consumers that would have carried out the investment even without the incentive), a lack of knowledge by targeted consumers preventing uptake of the subsidies, and high transaction costs or complex and long procedures to process forms that are too onerous for the applicants.

Monitoring Metrics

Monitoring metrics for industrial energy-efficient rewards and subsidy programs include:

- Number of applications for subsidies or rewards/year
- Number of projects deemed eligible for subsidies or rewards/year prior to initiation
- Number of projects that qualify for subsidies or rewards/year after completion
- Spending on subsidies or rewards/year
- Energy savings realized following completion of projects that received subsidies or rewards

Case Studies

Subsidies for Industrial Energy Efficiency Equipment, Japan

The New Energy and Industrial Technology Development Organization (NEDO) has managed a subsidy scheme to promote the installation of energy-efficient equipment in all sectors of the economy, including industry, since 1978. The total subsidies dispersed in 2007 were 83 billion YPI (5.5 billion RMB). For larger industrial companies, grants were available for large-scale investment projects that resulted in energy conservation equipment or technologies being adopted in existing factories and business

facilities. One third of the investment cost for the project could be subsidized with an upper limit per project of 500 million YPI (33.4 million RMB) (IIP, 2008). NEDO pays up to one-third of the cost of new high performance industrial equipment, such as furnaces. Compared with conventional industrial furnaces, high-performance industrial furnaces are capable of realizing an improvement of 30 percent or more in energy efficiency, as well as a reduction of about 50 percent in NO_x emissions. NEDO estimates that replacing all furnaces by high-performance furnaces will save 5% of Japan's final energy consumption by 2010 (Ayako, 2000).

Energy Rewards Program, New Hampshire, U.S.

The Public Service of New Hampshire (PSNH) offers rewards to commercial and industrial customers who have undertaken energy efficiency measures and achieved measurable energy savings. PSNH commercial and industrial customers, energy service companies, and other third party service providers representing commercial and industrial customers with a demand of 350 kW or more are eligible to participate. The minimum project energy savings for this program is 100,000 kWh per year (which may be the sum of multiple sites), and the minimum total project cost is \$200,000 (1.25 million RMB) (PSNH, n.d.). The program aims to replace old equipment with high efficiency equipment. Eligible measures include replacing standard fluorescent lighting with high efficiency fluorescent lighting, installing variable speed drives on motors, installing lighting controls to reduce lighting operating hours, and replacing low efficiency air conditioning equipment with high efficiency equipment. The rewards are not applicable to new construction projects, co-generation facilities, fuel switching, or repair or maintenance projects. In 2009, the total amount of grants for the PSNH Energy Rewards Program was \$300,000 (1.88 million RMB) (University of New Hampshire, 2011). The Energy Rewards Program was successful in overcoming a number of market barriers such as the high initial costs of energy efficiency upgrades and the restriction on municipal governments regarding long-term debt.

Ten Key Projects, China

The *Ten Key Projects* program is a key element of China's *Medium and Long Term Plan for Energy Conservation* and has been incorporated into the national 11th and 12th Five Year Plans. This program aims to reduce energy intensity and promote energy conservation and energy substitution in ten different project types including projects focused on the industrial sector such as those in the iron and steel, cement, and chemicals industries. In 2007, the Chinese central government allocated a total of 23.5B RMB to improve energy efficiency and abate pollution. The Ministry of Finance (MOF) and National Development and Reform Commission (NDRC) use a portion of this funding to award enterprises at a rate of 200 RMB for every tce saved per year for energy-saving projects in industrial enterprises in east China to 250 RMB for every tce per year for energy-saving projects in industrial enterprises in mid and west China related to the implementation of five of the Ten Key Projects. The rewards and rebates are paid to enterprises that have energy metering and measuring systems that can document proven savings of at least 10,000 tce. A recent estimate of the savings of the Ten Key Projects

for the production of power, steel, cement, ethylene, and synthetic ammonia based on information provided by NDRC on the improvement in energy intensity in these industries during the 11th FYP coupled with their production levels identified final energy savings of 204 Mtce if all of the savings are attributed to the Ten Key Projects and not to other energy-saving efforts such as the Top-1000 program (Ke et al., 2012).

Industrial Energy Efficiency Retrofits, Shanghai

During the 11th Five Year Plan, the Shanghai government implemented the national policies on Ten Key Projects and the fiscal rewards for energy retrofits and focused on five main industrial areas, including industrial boilers/furnaces upgrades, energy system optimization, motor system energy saving, waste heat and waste pressure utilization, and green lighting. Energy savings retrofits were incentivized with a fiscal reward of 300 RMB per tce for projects with a minimum of 500 tce savings. During 2006-2010, the Shanghai government implemented 804 industrial energy-efficiency retrofit projects, with a total investment of 11.17 billion RMB and estimated total energy savings of 2.45 Mtce (Shanghai Government Website, 2011).

Attributes

- Carbon Saving Potential
Medium
Based on the number of possible industrial energy-efficiency retrofit projects and the range of possible energy savings of the projects, it is estimated the total energy savings for cities is medium.
- First Cost to Government
High
Based on Shanghai's experience with a fiscal reward on energy savings of 300 RMB per tce, total costs for the government are estimated to be in the range of 200 million RMB to 700 million RMB for providing the subsidies to reward energy-savings gained from retrofits.
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced carbon dioxide and other pollutant emissions, improved energy efficiency, improved air quality, increased employment opportunities in the energy conservation and environmental protection industries, improved public health, and fuel and/or electricity savings.
NDRC (2011) reported that the implementation of the Ten Key Projects achieved economic and social benefits including improving energy efficiency, promoting advanced energy-saving technologies, and developing the energy conservation and environmental protection industries.

Tools and Guidance

The Industrial Assessment Centers (IACs) of the U.S. Department of Energy offer tools to improve energy efficiency, enhance environmental performance, and increase productivity of manufacturing plants. The focus is to improve system energy efficiency, including motor systems, steam systems, compressed air, combined heat and power, and process heating systems. The database of assessments from the IAC program contains over 80, 000 energy, waste, and productivity recommendations from over 15, 000 assessments conducted by the IAC program since 1982. These useful tools and the database for improving industrial energy efficiency are available at this website:

<http://www.iacforum.org/iac/tools.jsp>.

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I06: Industrial Energy Efficiency Loans and Innovative Funds

Description

Energy efficiency loans are loans subsidized by public funding that are offered at interest rates lower than the market rate for investments in industrial energy efficient technologies and equipment. Like subsidies, the goal of subsidized loans is to promote energy efficiency measures until they achieve a certain market acceptance level and can be funded on their own.

Innovative funds that are aimed at increasing the involvement of banks and private capital in energy efficiency investments are also being used in some countries. Innovative funds include equity participation through ESCOs, guarantee funds, revolving funds, and venture capital. ESCOs are private companies that provide project identification, engineering, design, installation, ongoing servicing and maintenance, monitoring and verification of savings, and/or financing of energy and energy efficiency projects. As a part of a private fund geared towards energy efficiency, the ESCO's role is to help to acquire and manage projects within the fund.

Guarantee funds provide a guarantee to the banks granting loans in the medium and long term. Guarantee funds for energy efficiency can be offered in addition to the national funds in order to cover credit risks associated with financing energy efficiency. France, Hungary, and Brazil have all established guarantee funds for energy efficiency.

With revolving funds, the reimbursement of the loans is recycled back into the fund to support new projects. These funds generally require public or national intervention to support them, either through subsidizing interest rates (low or zero) or by subsidizing the principal investment. They can be implemented at the local or national level and can be applied to any sector (Price et al., 2008).

Industrial energy efficiency loans and innovative funds can assist local governments to promote energy efficiency by making conducting energy-efficiency activities and investing in energy-efficiency projects more financially attractive. To achieve higher energy savings, this policy can be used in combination with conducting energy audits ("Energy Audit / Assessments"), implementing industrial energy plans ("Industrial Energy Plan"), meeting stretch targets ("Stretch Targets for Industry"), enforcing the minimum energy performance standards ("Industrial Equipment and Product Standards"), and investing low-carbon industrial parks ("Low-carbon Industrial Parks") as well as fuel-switching projects ("Fuel-switching").

Implementation Strategies and Challenges

Implementation Activity	Description
Identify implementing organizations	A bank or an independent and non-profit company is designated by the government to implement the low-interest loan for energy efficiency technology and measures.
Establish the program – issue guidance and setting criteria	The implementing organization issues guidance for offering energy efficiency loans and innovative funds for eligible equipment and measures. The implementing organization also defines criteria for determining the eligibility of equipment or measures or issues a qualifying technology list.
Participants apply for energy efficiency loans and innovative funds	Participants file necessary application documents in order to receive the corresponding energy efficiency loans and innovative funds.
Review, verify, and assess	The institution determines the applicant's status, undertakes a commercial credit check and establishes the estimated energy savings. Once a conditional loan offer has been made, a technical consultant will verify the equipment details and then conduct an energy saving assessment.
Monitor and evaluate	The responsible organization needs to monitor the amount of loans or funds that have been issued, and track the energy-efficiency performance of the applicants. The responsible organization also needs to periodically conduct an evaluation of the program to determine, for example, the cost-effectiveness of the loans and funds.

Some possible challenges for implementing industrial energy efficiency loans and innovative funds include: compared to subsidies, public loans are less attractive to consumers, high risk market environments may make it difficult to raise financing from banks that tend to be conservative in investments and are not used to the idea of energy efficiency generating cash, and guarantee funds are usually not adequate to support financing for energy efficiency projects.

Monitoring Metrics

Monitoring metrics for industrial energy efficiency loans and innovative funds include:

- Number and size of energy efficiency loans per year
- Annual energy savings from projects implemented through energy efficiency loans

- Annual CO₂ emission reduction from projects implemented through energy efficiency loans

Case Studies

Carbon Trust, UK

<http://www.carbontrust.com/home>

The UK's Carbon Trust is a government-funded independent non-profit organization that assists businesses and the public sector to reduce carbon emissions by 60% by 2050 as outlined in the UK Government's Energy White Paper. The Carbon Trust provides interest-free loans to small- and medium-sized enterprises ranging from £ 5,000 (47,211 RMB)³⁸ to £ 200,000 (1.89 million RMB) (and up to £ 400,000 (3.78 million RMB) in Northern Ireland). In addition, the Carbon Trust funds a local authority energy financing scheme, promotes the government's Enhanced Capital Allowance Scheme, and has a venture capital team that invests between £250,000 (2.36 million RMB) and £1.5 million (14.16 million RMB) per deal as a minority stakeholder alongside private sector investors. Venture capital investments include early-stage carbon reduction technologies as well as management teams that can deliver low carbon technologies.

Mississippi Energy Efficiency Investment Fund, U.S.

<http://www.mississippi.org/>

The energy efficiency investment fund provides loans to commercial and industrial sectors that promote the development and demonstration of efficient, environmentally acceptable, and commercially feasible technology and processes, and that also utilize Mississippi's existing energy resources, public utilities, and/or develop resources that foster economic growth. Eligible industries include manufacturers, warehouses, and distribution centers, research and development facilities, retail, telecommunications and data processing facilities, and national or regional headquarters. Renewable energy technologies include solar thermal, solar space heat, solar process heat, photovoltaics, alternative fuels, geothermal, biomass, landfill gas, and hydropower. All projects must demonstrate a reduction in the facility's energy costs. Funding comes from oil overcharge restitution funds from the U.S. Department of Energy. The total program fund is \$7 million (43.6 million RMB). The loan range permitted is \$15,000-\$500,000 (93,362 RMB – 3.1 million RMB) with the interest rate 2% below the prime rate and a maximum loan term of 10 years. The Mississippi Development Authority Energy Division administers the energy investment loan program, and requires a 1% good faith deposit on projects involving real estate pledges as collateral.

³⁸ Currency conversion is based on:

<http://www.xe.com/currencyconverter/convert/?Amount=1&From=USD&To=CNF>.

Energy Efficiency Revolving Loan Fund (EE RLF), New Jersey, U.S.

http://www.njeda.com/web/Aspx_pg/Templates/Npic_Text.aspx?Doc_Id=1465&menuid=1514&topid=718&levelid=6&midid=1175

The New Jersey Economic Development Authority (EDA) offers loans to commercial, institutional, and industrial entities that have received support under the New Jersey Office of Clean Energy Pay for Performance energy efficiency incentive program, the Large Energy Users Pilot Program, and the Small CHP and Fuel Cells Incentive Program. Low interest-rate loan amounts range from \$250,000 (1.56 million RMB) to \$2.5 million (15.6 million RMB), limited to 80% of the cost of the project (total state funding may not exceed 100% of project costs). Interest rates under the program vary with terms of 3 years (2%), 5 years (3%), and 7 years (4%). There is a minimum 1.1:1 debt service coverage ratio. Personal guarantees are required for any person or entity with 10% or more ownership in a project. Applicants must provide evidence of source of funds needed to complete a project. The Board of Public Utilities will take a lien on equipment to be financed, business assets and/or collateral. Business should create or maintain jobs in New Jersey.

China utility-based energy efficiency finance program

http://www1.ifc.org/wps/wcm/connect/regprojects_ext_content/ifc_external_corporate_site/home_ch_uee/news/press+releases/pressrelease3

Industrial Bank, a pioneer in providing energy efficiency financing in China, and the International Finance Corporation (IFC), a member of the World Bank Group, together initiated the second phase of China Utility-based Energy Efficiency Finance Program in 2008. According to the agreement, IFC will provide a \$100 million (622.5 million RMB) risk-sharing facility to Industrial Bank that will help the bank extend \$210 million (1.31 billion RMB) in energy efficiency loans. This initiative is expected to help reduce 5 million tons of carbon dioxide emissions a year, the equivalent of replacing ten 100-megawatt coal-fired power plants in China. In 2006, IFC provided a risk-sharing facility of up to \$25 million (155.6 million RMB) for Industrial Bank's "green" loans. In turn, the bank has financed 46 energy efficiency and greenhouse gas emissions reduction projects, for a total loan amount of 900 million RMB. The majority of these loans are to small and medium enterprises that are implementing energy efficiency projects such as industrial boiler retrofitting, waste heat recovery, co- and tri-generation projects for district heating, power saving, and optimization of industrial energy uses. Implementation of these projects are expected to reduce carbon dioxide emissions by more than 3.5 million tons a year, the equivalent of emissions from all 70,000 taxis currently running in Beijing for three years.

Attributes

- Carbon Savings Potential
Medium
The savings potential depend on the average realized energy savings of the energy-efficiency projects invested under the energy-efficiency loans and funds, as well as the number of projects invested. Based on the experiences of the China utility-based energy efficiency finance program, the energy-savings and carbon dioxide emission reductions potential for industrial energy efficiency loans is estimated to be medium.
- First Cost to Government
High
Based on China Utility-based energy efficiency finance program, the average loan amount per ton of CO₂ emission reduction was 257 RMB/ton. For local cities, the first cost for government to issue energy-efficiency loans and funds in order to achieve their energy-saving targets is estimated to be high.
- Speed of Implementation
>3 years
- Co-Benefits
Reduced carbon dioxide emissions, improved air quality, enhanced public health, increased employment opportunities, financial savings for enterprises.

Tools and Guidance

Carbon Trust Tools. <http://www.carbontrust.com/resources/tools>.

Leveraging Carbon Finance for Sustainable Development. United Nations Development Programme. 2007. http://www.mdgcarbonfacility.org/downloads/MDGCF_Brochure_English_07.pdf.

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I07: Tax relief

Description

Tax relief is a fiscal incentive used to promote adoption of industrial energy-efficiency technologies and measures through reducing the tax paid by consumers or enterprises related to the purchase of these technologies. Tax relief includes: 1) *accelerated depreciation* where purchasers of qualifying equipment can depreciate the equipment cost more rapidly than standard equipment, 2) *tax reduction* where purchasers can deduct a percentage of the investment cost associated with the equipment from annual profits, or 3) *tax exemptions* where purchasers are exempt from paying customs taxes on imported energy-efficient equipment.

These types of tax relief policies encourage businesses to purchase new and energy efficient assets and have been introduced in many countries including Canada, Germany, Japan, Republic of Korea, the Netherlands, Singapore, the U.S., and the UK. By promoting investment in energy-efficiency, this policy also can facilitate achievement of other policy goals, such as encouraging plants to adopt energy-efficiency measures after conducting energy audits (see “Energy Audit / Assessments”), attracting industrial companies to realize deeper energy-saving opportunities under their industrial energy plans (“Industrial Energy Plan”) and stretch targets (“Stretch Targets for Industry”), incentivizing industrial enterprises to investing in projects within low-carbon industrial parks (“Low-carbon Industrial Parks”), and making fuel-switching projects (“Fuel-switching”) to be more cost-effective. While Industry tax relief is typically determined at the national level, cities have conducted pilot programs or augmented national programs with additional tax incentives.

Implementation Strategies and Challenges

Implementation Activity	Description
Identify implementing organizations	The local government entity with authority to provide tax relief policies should be designated to investigate the feasibility of implementing tax relief-type policies.
Establish the tax relief policies	The implementing organization issues guidance for claiming a tax credit or accelerated depreciation for eligible equipment and measures. The implementing organization also defines criteria for determining the eligibility of equipment or measures or issues a qualifying technology list.
Enterprise installs equipment	Enterprise installs energy-efficient equipment and documents purchase/installation.
Tax relief	Participant files necessary tax documents in order to

	receive the corresponding tax relief.
Monitor and evaluate	The implementing organization monitors the amount of tax relief that is disbursed, the technologies or projects that were installed in order to claim the tax relief, and track the energy-efficiency performances of the applicants. The implementing organization also needs to conduct evaluation of the program effectiveness.

Implementation challenges could include setting proper tax relief rates, selecting suitable energy-efficiency technologies, and verification of technology adoption rates and energy-savings.

Monitoring Metrics

Monitoring metrics for tax relief programs include:

- Number of energy-efficiency measures that receive tax relief each year
- Total investment costs of each energy-efficiency measure
- Annual energy savings of each energy-efficiency measure

Case Studies

Energy Efficiency Tax Incentives, Oregon, U.S.

Among the 11 U.S. states that have a total of 15 energy efficiency tax incentives available to industry, Oregon offers industry the largest number of energy efficiency tax incentives, including:

- 1) Tax credit for businesses that invest in energy conservation, recycling, renewable energy resources, and less-polluting transportation fuels, offering a credit of 35%-50% of the cost of the system or equipment. For qualifying renewable resource projects, the tax credit is 50% of the eligible project costs. For other projects, the tax credit is 35% of the eligible project costs.
- 2) Tax credit for energy efficient equipment installed during construction, as well as up to 35% of the costs associated with ensuring the project exceeds industry standards.
- 3) Tax incentive for 50% of the cost of combined heat and power projects.
- 4) Sustainable building tax credit offered to businesses with buildings that meet the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) standards.

From 2000 to 2010, while Oregon's real gross state product grew at an annual average rate of 3.7%. During the same period, energy consumption per dollar of gross product decreased by 31.1% (BEA, 2013; EIA, 2013).

Application of the taxation system for promoting investment in the reform of the energy supply and demand structures, Japan

Japan has implemented a tax system to promote investment in energy-efficient technology in the industrial sector. This system allows individuals and corporations to claim a tax credit or accelerated depreciation for eligible equipment. The tax credit is equivalent to 7% of relevant equipment acquisition costs to be deducted from the corporate tax amount and the depreciation covers 30% of the equipment acquisition cost in the initial year (METI and ECCJ, 2009).

Energy Investment Allowance (EIA), Netherlands

The Energy Investment Allowance (EIA) is a tax relief program in The Netherlands that provides a tax deduction to companies that invest in energy-saving equipment and sustainable energy. Entrepreneurs may deduct 41.5% of the invested sum from their taxable profits from the year in which the goods are purchased. The minimum amount of energy-saving investment is €2300 (18,639 RMB)³⁹ a year. No investment allowance is granted for investments exceeding €118 million (956 million RMB) per year. The Ministry of Economic Affairs, the Ministry of Housing, Physical Planning & Environment, and the Ministry of Finance compile a Technology Eligibility List annually that lists the technologies that are eligible for the scheme (e.g. heat pumps, cogeneration plants, energy-efficient lighting systems, etc.). In 2012, the list contained more than 130 different technologies. New technologies can be added to the list each year, and others withdrawn (Tax Consultants International, 2012).

Energy Efficiency Tax Incentives Regulation, South Africa

In South Africa, companies can earn a tax break by providing evidence of energy efficiency savings. The energy efficiency saving certificates are issued by the National Energy Development Institute (SANEDI) after approving the achieved energy savings. The policy was initially proposed in 2011, and the government has allocated ZAR 20 billion until 2015 (15 billion RMB per year)⁴⁰. To be qualified for the incentives, all projects need to be manufacturing-related and must result in a minimum 10% energy reduction in the year that the investment is realized (IIP, 2012).

³⁹ Based on 2012 Euro to RMB average exchange rate: 1 Euro = 8.104 RMB
(<http://www.oanda.com/currency/historical-rates/>)

⁴⁰ Based on 2012 South Africa Rand (ZAR) to RMB average exchange rate: 1 ZAR = 0.7682 RMB
(<http://www.oanda.com/currency/historical-rates/>)

Attributes

- Carbon Savings Potential
Medium
Energy savings and emission reductions are in the low to medium range depending on how many enterprises participate in the tax relief program, and the effectiveness of the program.
- First Cost to Government
High
More information is needed in order to determine the costs to implement this policy for local governments. Based on case studies from Germany and South Africa, it is estimated the cost of tax reliefs in China will be in the high range. The estimation is calculated based on Shanghai's conditions and used international experiences.
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced carbon dioxide emissions, improved air quality, increased employment opportunities, energy and/or financial savings

Tools and Guidance

Glatt, S., 2010. *State energy efficiency tax incentives for industry*. Office of Industrial Technologies Program. Golden Field Office. U.S. Department of Energy. Available at: http://www1.eere.energy.gov/manufacturing/states/pdfs/state_ee_tax_incentives_for_industry.pdf.

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Ministry of Economy, Trade and Industry (METI) and the Energy Conservation Center of Japan (ECCJ), 2009. "Questions & Answers for Application of the Taxation System for Promoting Investment in the Reform of the Energy Supply and Demand Structures." Available at: <http://www.asiaeec-col.eccj.or.jp/brochure/pdf/qanda.pdf>

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I08: Energy or CO₂ Taxes

Description

Energy or energy-related carbon dioxide (CO₂) taxes have been used in a number of countries to provide an incentive to industry to improve the energy management at their facilities through both behavioral changes and investments in energy efficient equipment. Taxes on energy or energy-related CO₂ emissions were first adopted in a number of northern European countries in the early 1990s. Such taxes are now found in Austria, the Czech Republic, Denmark, Estonia, Finland, Germany, Italy, the Netherlands, Norway, Sweden, Switzerland, and the UK. In target-setting programs that involve the use of energy taxes, such as the Climate Change Agreements in the UK and the Danish energy efficiency agreements, rewards for meeting agreed-upon targets are provided in the form of a reduction of the required energy tax. The French AERES agreements include a penalty fee imposed at the end of two evaluation periods if the targets are not met. Energy or CO₂ taxes on enterprises can be used as a component in energy efficiency programs (e.g. along with energy audits and benchmarking) or to provide tax rebates to enterprises that reach their targets. The Intergovernmental Panel on Climate Change found that “emission taxes do well in both cost effectiveness and environmental effectiveness”.

By providing economic incentives, this policy can be used in combination with other policies on industrial energy efficiency, such as energy audits (see “Energy Audit / Assessments”), industrial energy action plans (“Industrial Energy Plan”), investing in low carbon industrial parks (“Low-carbon Industrial Parks”), and investing in fuel-switching projects (“Fuel-switching”).

Implementation Strategies and Challenges

Implementation Activity	Description
Identify implementing organizations	The local government designates an existing governmental agency to implement the policy or establishes a new commission to oversee implementation of the policy.
Set the tax base	To implement energy or carbon taxes, the government must decide which fuels or sectors will be taxed. Most commonly, energy or carbon taxes are placed on gasoline, coal, natural gas, and electricity, and are applied to the industry, commerce, agriculture, and public sectors.
Decide the tax rate	The energy or carbon tax rate are set by the implementing organization. Best practice is to set these tax rates based on the social marginal costs from producing an additional unit of emissions and the social marginal benefits from abating a unit of emissions. The implementing agency may need to seek outside expertise to conduct a study to determine these cost and benefit levels.
Establish the revenue redistribution	The implementing agency establishes the process for

	redistribution of the energy or carbon tax revenues. Revenues can be used to fund energy efficiency and carbon mitigation programs, rebated to companies that reach specified energy-saving or emissions reduction targets, or used to supplement government budgets, or a combination of these options. The choice of revenue distribution could impact the political sustainability of the tax.
Enact the start-up plan	The implementing agency should decide whether to start the full tax immediately or phase it in over time. A slow ramp-up would gradually introduce the tax over time, by starting with a low initial rate or a narrow initial base and then increasing the rate or base at a pre-announced schedule to reach the desired system.
Adjust the tax rate periodically	Tax rates can be adjusted periodically to reflect new information about the marginal cost and the marginal benefit of abatement.
Measurement and verification	Measurement and verification are needed to determine energy savings and the overall effectiveness of the tax as well as to provide a basis for future tax adjustments.

Some possible challenges for implementing this policy include: lack of authority or ability to impose an energy or CO₂ tax; ineffective program design; difficulty in setting up an appropriate tax rate; and collected tax not redistributed appropriately for supporting energy-efficiency or low-carbon programs.

Monitoring Metrics

Monitoring metrics for energy or CO₂ taxes include:

- Number of participating companies and sectors
- Annual tax rate by fuel type and by sector
- Annual revenues from the program
- Redistribution of the revenues
- Annual energy savings
- Annual CO₂ emissions mitigation

Case Studies

Carbon Dioxide Tax, Denmark

In 1990, the Danish government set a goal of reducing CO₂ emissions by 20% in 2005 compared to 1988 levels. In addition, under the Kyoto Protocol and the following European Union burden-sharing agreement, Denmark was also obligated to reduce greenhouse gas (GHG) emissions by 21% compared to 1990 emission levels by 2008-2012. In support of the national CO₂ reduction target, a CO₂ tax was introduced in Denmark on May 15, 1992 for households and January 1, 1993 for industry. The purpose

of the tax was to address environmental protection issues as well to cover fiscal gaps and support a growing national economy by redirecting the tax revenues to the economy. All fossil-fuel burning households were required to pay €13.4 per tonne CO₂ (108 RMB/tonne CO₂). However, value-added tax (VAT)-registered businesses were only required to pay €6.7 per tonne CO₂ (54 RMB/tonne CO₂) (Svendsen, 2007), to address concerns over international competitiveness and domestic employment. In 1996, the Danish government established the Green Tax Package, which included an additional CO₂ tax, a new SO₂ tax, and new energy taxes on space heating. The energy tax was imposed on energy consumption used for ordinary space heating including hot water. During 1996-1998, the energy tax was about €5.5 per GJ (44.4 RMB/GJ). After 1998, the level of energy tax was increased to about €6.8 per GJ (54.9 RMB/GJ) (DEA, 2005; DEA, 2000). SO₂ tax was gradually introduced since 1996. Currently, it is €1.34 (10.8 RMB) per kilogram of emitted SO₂, or €2.68 (21.6 RMB) per kilogram of sulfur in the fuel. In Denmark, approximately 40% of tax revenue is used for environmental subsidies, while the other 60% is returned to industry (Danish Energy Agency, 2011).

Swedish Carbon Tax, Sweden

In 1991, the Swedish Carbon Tax was introduced. Industries were only required to pay 50% of the tax to maintain competitiveness and certain high energy-using industries such as commercial horticulture, mining, manufacturing, and the pulp and paper industry were fully exempted from the tax. In 2004, an EU directive led to an increased electricity tax of €0.5/MWh (4.03 RMB/MWh) which affected most Swedish industrial companies. As a result, the Program for Improving Energy Efficiency in Energy-Intensive Industry (referred to as “PFE”) was introduced. At the end of PFE’s second year in 2006, 117 companies representing about one fifth of Sweden’s total electricity consumption were participating in the program. Nearly all of the companies have now submitted their first reports on energy efficiency improvement activities undertaken, including energy audits and analysis of their energy use as well as introduction of certified energy management systems. In 2006, 98 companies submitted their two-year report and outlined nearly 900 energy efficiency improvements that they plan to undertake by 2009. The improvements will cost the companies about €110 million (887.5 million RMB) and reduce electricity consumption by 1 TWh/year, saving €55 million (443.7 million RMB) per year. In addition, the companies will receive €17 million (137.2 million RMB) tax reductions through their participation in this program (Johansson, 2000).

UK Climate Change Program, UK

The UK Climate Change Program was established in 2000 to meet both the country’s Kyoto Protocol commitment of a 12.5% reduction in GHG emissions by 2008-2012 relative to 1990 and the domestic goal of a 20% CO₂ emissions reduction relative to 1990 by 2010 (DEFRA, 2006). A key element of the Climate Change Program is the Climate Change Levy (CCL), a tax on the use of energy (natural gas, coal, liquefied petroleum gas, and electricity) applied to industry, commerce, agriculture, and the public sector. The levy is “downstream”, i.e. is paid by energy users rather than extractors or generators, and is

structured so as to encourage renewable energy but not nuclear power. The Climate Change Agreements (CCAs) have been administered by the UK Department of Energy and Climate Change (DECC) since October 2008, and ended in March 2013. During this time period, companies that met their agreed-upon targets are given an 80% discount from the CCL (Price, et al., 2010). A new CCA scheme is administered by the Environmental Agency from April 1, 2013 to March 31, 2023. Under the new CCA program, the discounted CCL for electricity is increased to 90%, while discounts for other fuels are reduced to 65% (UK Environmental Agency, 2013). Anyone over-complying with their agreement target can trade the resulting credits into the UK emissions trading scheme, along with permits allocated under that scheme and renewable energy certificates under a separate renewable constraint on generators. The revenues from the levy are returned to the taxed sectors through a reduction in the rate of employer's National Insurance Contributions and used to fund programs that provide financial incentives for adoption of energy efficiency and renewable energy.

Attributes

- Carbon Savings Potential
High
Due to the impact of carbon taxes, Sweden's emissions were reduced by almost 9% between 1990 and 2006, while in Denmark, per capita emissions were reduced by 15% between 1990 and 2005. In UK, emissions decreased by more than 96 Mt CO₂ from 2001 to 2010 (Price, et al., 2010; AEA, 2011).
- First Cost to Government
Low
As the energy or CO₂ tax is levied on enterprises, the costs for governments are estimated to be low. Governments need to bear the costs of managing and supervising the program.
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced carbon dioxide and other air pollutant emissions, improved air quality, enhanced public health, increased productivity, increase energy efficiency, increased energy savings

Tools and Guidance

Carbon Tax Center. Available at: <http://www.carbontax.org/>.

Sherlock, M., 2012. "Energy tax incentives: measuring value across different types of energy resources." U.S. Congressional Research Service. September 2012. Available at: <http://www.fas.org/sgp/crs/misc/R41953.pdf>.

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I09: Industrial Equipment and Product Standards

Description

Product energy performance standards that prescribe requirements for minimum energy performance of specific products are commonly used for appliances and office equipment, but are not commonly used for industrial equipment and products. Exceptions include motors, industrial boilers, and transformers. Mandatory minimum energy performance standards for three-phase induction motors are prescribed in Australia, Brazil, Chinese Taipei, Costa Rica, Israel, Mexico, New Zealand, China, South Korea, and the U.S.; voluntary standards for the same motors are prescribed in the EU, India, and Malaysia. Mandatory minimum performance standards for oil-fired boilers are prescribed in Canada, Chinese Taipei, and the EU. The principle of setting a minimum energy performance standard is to achieve maximum efficiency that is technologically feasible and economically justified.

An assessment of energy-efficiency standards in the Netherlands found that industrial firms prefer energy and carbon taxes to standards, but especially prefer subsidies and voluntary agreements. Experience to date with energy-efficiency standards for industry is “not encouraging” (Blok et al., 2004).

To assist industrial companies to meet the minimum energy performance standards, local governments can provide multiple energy-efficiency programs for industrial companies to participate, such as benchmarking (see “Benchmarking”), energy audits (“Energy Audit / Assessments”), and training workshops on energy management (“Energy Manager Training”).

Implementation Strategies and Challenges

Implementation Activity	Description
Identify implementing organizations	The local government designates an existing governmental agency, a local research institution, or a third party to implement the policy. The local government could also establish a new commission to lead the policy as well.
Formulate a product standard	The designated implementing organization designs a product minimum energy performance standard, often working collaboratively with stakeholders.
Streamline data reporting	The designated implementing organization can assist the data reporting process by developing a template, tool, or an online reporting system for data gathering. Then, industrial enterprises submit energy use and production data to the responsible implementing organization.

Review and evaluate submitted data	The designated implementing organization reviews the energy and production data submitted by industrial enterprises and evaluate if the industrial enterprises have met the minimum energy performance standards. The evaluation could be based on random checking and focus on the high energy-intensive industrial sectors.
Information dissemination	The designated implementing organization can award the industrial enterprises that have met the advanced performance by public announcements, or publishing best practices and case studies.

Some implementing challenges could include lack of financial support to develop and update industrial product/equipment standards over time, lack of verification of the energy use of industrial products/equipment, and lack of technical assistance and financial incentives for industrial enterprises to invest in products that meet the standards.

Monitoring Metrics

Monitoring metrics for enforcement of industrial equipment and product standards include:

- Number of new industrial product/equipment standards
- Market penetration of products covered by standards
- Annual energy savings and CO₂ emissions reduction associated with new standards

Case Studies

Minimum Efficiency Standards for Electric Motors, U.S. Department of Energy

http://www1.eere.energy.gov/femp/technologies/eep_emotors.html

The Energy Independence and Security Act of 2007 (EISA), which raised U.S. minimum efficiency standards for general-purpose, single-speed, poly-phase induction motors of 1 to 500 horsepower (hp), went into effect in December 2010. Certain motors are required to have nominal full load efficiencies that meet the levels defined in NEMA MG-1 (2006). Motors manufactured after December 2010 must comply with the law.

NEMA Premium Motors Program, U.S. National Electrical Manufacturers Association

<http://www.nema.org/Policy/Energy/Efficiency/Pages/NEMA-Premium-Motors.aspx>

The member companies of the U.S. National Electrical Manufacturers Association (NEMA) Motor and Generator Section established a NEMA Premium energy efficiency motors program to provide highly energy-efficient products that meet the needs and applications of users and original equipment manufacturers (OEMs) based on a consensus definition of "premium efficiency" and use of the NEMA Premium logo for premium products. NEMA Premium-labeled electric motors assist purchasers in optimizing motor systems efficiency, reducing electrical power consumption and costs, and improving system reliability. It is estimated that the NEMA Premium efficiency motor program will save 5,800 GW of electricity in the U.S. over the next ten years. This translates to preventing nearly 80 million metric tons of carbon dioxide into the atmosphere -- equivalent to keeping 16 million cars off the road.

Premium Efficiency Transformers Program, U.S. National Electrical Manufacturers Association

<http://www.nema.org/Technical/Pages/NEMA-Premium-Efficiency-Transformers-Program.aspx>

The National Electrical Manufacturers Association (NEMA) set the standard for the efficiency of various types of distribution transformers with the publication of *NEMA TP 1-2002 Guide for Determining Energy Efficiency for Distribution Transformers*. The NEMA standard was later adopted by the U.S. Department of Energy (DOE) as the national energy-efficiency rule for low-voltage dry-type distribution transformers. The new NEMA Premium Efficiency Transformer designation requires 30 percent fewer losses than existing DOE regulations (10 CFR 431) for low-voltage dry-type distribution transformers. Ten major manufacturers have committed to providing NEMA Premium Efficiency Transformers to the marketplace. Based on data from the U.S. Department of Energy, it is estimated that new transformer efficiency standards will reduce CO₂ emissions by 238 million metric tons over equipment lifetimes, and provide net present energy savings of \$1.39 billion (NEMA, n.d.). The NEMA Premium program will accelerate these benefits by deploying efficient transformers faster than required by law.

Minimum Energy Efficiency Standards for Industrial Products in China

China has published 27 national standards for high energy-consuming industrial products, including sectors such as cement, iron and steel, and non-ferrous metals. These standards include three types of indicators for energy-efficiency performance, including: 1) maximum energy use (or minimum energy efficiency) per unit of production for existing plants; 2) maximum energy use per unit of production for new plants; and 3) advanced energy efficiency level per unit of production, based on domestic or international best practices. The first of the three indicators, i.e., the minimum energy performance standards for existing plants is a mandatory requirement for industrial plants. The Ministry of Industry and Information Technology in China is responsible for enforcement of these standards.

Attributes

- Carbon Savings Potential
Medium
The energy-savings potential for enforcing energy-efficiency standards on industrial equipment and standards is estimated to be medium, given the coverage of industrial equipment and standards and the number of equipment and standards used in industrial sectors. Standards should also gradually become more rigorous over time, so the energy-efficiency level of the whole market can be improved.
- First Cost to Government
Low
In general, appliance and equipment standards are set at levels that are deemed to be cost-effective over the lifetime of the product. The costs to the government to enforce the standards are estimated to be low, compared with other energy-efficiency programs. Random inspections, required reporting, or fines on violations of the standards could be used.
- Speed of Implementation
<1 year
- Co-Benefits
Reduced carbon dioxide emissions, improved air quality, increased productivity, energy and cost savings for companies.

Tools and Guidance

Collaborative Labeling and Appliance Standards Program (CLASP). Resource and tools. Available at: <http://www.clasponline.org/ResourcesTools>.

Energy Efficiency Standards, 2013. *The Standard Setting Process*. Lawrence Berkeley National Laboratory. Available at: <http://ees.ead.lbl.gov/node/2>. [Accessed on March 28, 2013]

U.S. Department of Energy, 2013. *Implementation, Certification and Enforcement*. Available at: http://www1.eere.energy.gov/buildings/appliance_standards/implement_cert_and_enforce.html [Accessed on March 28, 2013].

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I10: Differential Electricity Pricing for Industry

Description

In June 2004, China's National Development and Reform Commission (NDRC) established a policy permitting differential electricity pricing for high energy-consuming industries, including electrolytic aluminum, ferroalloy, calcium carbide, caustic soda, cement, and steel, in which electricity prices are set based on the energy intensity levels of industrial enterprises. Under this policy, enterprises were grouped into one of four categories based on their level of energy-efficiency: encouraged, permitted, restricted, and eliminated. The electricity price varied between different categories and was designed to phase-out inefficient enterprises and encourages efficient ones (Moskovitz et al., 2007). Enterprises in the "encouraged" and "permitted" categories paid the normal price for electricity in their areas. Enterprises in the "restricted" and "eliminated" categories paid surcharges of 0.05 RMB and 0.20 RMB per kWh (US\$0.0060/kWh and US\$0.0242/kWh)⁴¹, respectively. As of 2006, 30 provinces (33 in total) had implemented this policy, covering approximately 2,500 enterprises. Between 2004 and 2006, approximately 900 firms in the eliminated category and 380 firms in the restricted category had closed, invested in energy efficiency, or changed production processes (Moskovitz et al., 2007). In 2007, the policy was adjusted to allow local provincial authorities to retain revenue collected through the differential electricity pricing system, providing stronger incentives for provincial authorities to apply the policy (Moskovitz, 2008).

The differentiated electricity pricing policy, however, has not yet been fully implemented across China. In some areas, preferential (reduced) electricity prices were provided to some high-energy-consuming industries without authorization. This contributed to the very rapid and unplanned development of these industries. In September 2006, the State Council gave NDRC the authority to prohibit or halt preferential electricity pricing and expanded the coverage of the industries subject to differential pricing to include phosphorus and zinc smelting industry. Importantly, it further increased the electricity price for "eliminated" enterprises to 50% higher than the price for high-energy-consuming industries, over a three-year period and immediately increased the price differential for "eliminated" enterprises by a factor of four to 0.20 RMB per kWh (US\$0.0252/kWh), and for "restricted" enterprises by a factor of 2.5, to 0.05 RMB per kWh (US\$0.0063/kWh) (NDRC, 2006).

The increased revenues generated from the differentiated electricity pricing policy could be collected by government authorities and redistributed to other energy efficiency programs. Although this type of program has not been implemented yet in China, this design could make the policy more effective in incentivizing energy-efficient production and would generate more funding for other energy-efficiency programs.

Differentiated electricity pricing can be used in combination with other industrial energy-efficiency policies to help achieve other policy goals, such as enforcement of minimum energy performance standards on industrial products (see policy "Industrial Equipment and Product Standards"), adopting

⁴¹ Based on a currency conversion of \$1 = 7.9897 RMB (average rate of July 2006).

energy management standards (“Energy Management Standards”), and investing in energy-efficiency projects.

Implementation Strategies and Challenges

Implementation Activity	Description
Identify implementing organizations	The local government identifies an existing governmental agency to implement this program. The local government could also establish a new commission to oversee the implementation of the policy.
Assess enterprise performance	Gather data, assess performance of all major facilities, and establish a baseline for measuring future results of efficiency efforts. Key tasks include: gather and track data, establish baseline, and conduct benchmarking.
Issue differential electricity pricing policy	Based on the evaluation, the designated implementing organization issues the differential electricity price policy stipulating the effective time and scope, standards, and enforcement measures.
Implementation, measurement, and verification	In the implementation phase, measurement and verification can be applied to determine the overall implementation and effectiveness of the policy, which is very important for future policy adjustment and revision.
Information dissemination	The designated implementing organization can make the implementation, measurement and verification documents publicly available. Information on best practices, experiences, lessons learned, and case studies should also be disseminated to other industrial enterprises.

Some possible challenges for implementing differential electricity pricing include lack of authority to set differential electricity rates, difficulties in assessing enterprise performance, establishing baselines, and undertaking benchmarking due to data issues; ineffective design of differential electricity prices; revenues collected from the differential electricity pricing system are not redistributed effectively to energy efficiency improvement program; lack of related policies and programs to help high-energy consuming industries to improve their energy efficiency.

Monitoring Metrics

Monitoring metrics for differential electricity pricing for industry include:

- Number of enterprises subjected to differential electricity pricing in each category
- Annual revenues from the policy
- Redistribution of the revenues (e.g., to energy-saving programs)
- Annual improvement of energy intensity
- Annual CO₂ emission reductions

Case Studies

Guangdong, China

http://govinfo.nlc.gov.cn/lssj/xxgb/gdzfgb/282704a/201201/t20120104_1282971.html?classid=373

Guangdong introduced differential electricity prices on June 1st, 2010 in response to the central government's call to promote energy efficiency. Electricity prices were increased for enterprises in the categories of "eliminated" and "restricted". Eight heavy industries including steel and cement are covered under this policy. This policy was later expanded to eleven more highly-polluting sectors, including light industries. Since then, differential electricity prices have covered all the major sectors of high energy consumption and high pollution in Guangdong Province. The electricity prices for several sectors are even higher than the national standards. In addition, Guangdong Province also introduced punitive electricity prices to enterprises whose energy consumption per unit of product exceed the local and national standards. In 2010, twelve enterprises were penalized under this policy.

Shanghai, China

<http://english.people.com.cn/90001/98986/7006244.html>

Shanghai imposed a differential electricity pricing policy on eight energy-intensive industries on June 1st, 2010. The government increased electricity prices of "restricted enterprises" from 0.05 RMB per kWh to 0.15 RMB per kWh and prices for "enterprises to be eliminated" from 0.2 RMB per kWh to 0.4 RMB per kWh. The revised differential power pricing system was scheduled to be phased in over two years. The government also used a punitive pricing policy on those energy-intensive enterprises, which exceed the national and local standards on minimum energy performance for industrial products. Enterprises that did not meet the national and local standards need to pay for even higher power prices (increased by 0.1 RMB - 0.3 RMB per kWh) for the increased electricity usage.

Fujian, China

<http://www.fjetc.gov.cn/zfxxgk/newsInfo.aspx?newsid=18703>

Fujian imposed a differential electricity price policy on eight energy-intensive industries starting on June 1st, 2010. The government increased electricity prices of restricted enterprises from 0.05 RMB per kWh to 0.1 RMB per kWh and prices for enterprises to be eliminated from 0.2 RMB per kWh to 0.3 RMB per kWh. If industries exceed the national and local minimum energy performance standards on industrial products more than once, a punitive price would be charged according to the regulation on elimination of enterprises. A recent case study on the use of differential electricity pricing in the cement industry of Fujian Province found that after two years of implementation of this policy, 19.6 Mt of outdated cement production capacity was closed, reducing coal use by 1.8 Mt and reducing CO₂ emissions by 4.26 MtCO₂. The total revenues from differential electricity pricing for the cement industry were 57.93 million RMB in 2007 and 126 million RMB in 2008. By June 2009, a total of 80.28 million RMB from these revenues was redistributed to the cement industry (Fuzhou Electricity Regulatory Office of SERC, 2009).

Shandong, China

In Shandong Province, an energy quota system was implemented, covering 20 industries (not including the eight heavy industries that have been covered by the national policy) and 52 manufacturing products. The quotas are set for energy consumption, including both electricity and other fuels. Industrial plants that exceed the quota level are required to pay a high penalty fee, which could be as high as 400 percent of the energy price (Moskovitz, 2008). The surcharged fees are collected and then redistributed by the Shandong Energy Conservation Supervision Center to be used in a special energy-efficiency investment fund.

Attributes

- Carbon Savings Potential

Medium

Based on the experiences in local provinces, differential electricity pricing played an important role in phasing out inefficient high energy-consuming industrial enterprises. The energy saved from closing down inefficient energy-intensive plants is significant. However, currently this policy is only targeted at existing industrial plants and has been viewed as a temporary policy to have a one-time effect of shutting down inefficient plants. More measures could be developed based on this policy – such as linking this policy to the new construction of industrial plants, or setting up a penalty system. Thus, the energy-savings and carbon dioxide emissions reduction potential is estimated to be medium.

- First Cost to Government

Low

The costs for local governments to develop this policy are considered to be low. Several local pilots have been conducted and the national policy has also been implemented. Local cities can apply this policy, based on local conditions and experiences from the provinces that have implemented differential electricity pricing.

- Speed of Implementation

1-3 years

- Co-Benefits

Reduced carbon dioxide and other air pollutant emissions, improved air quality, enhanced public health, increased energy efficiency, increased energy savings, increased government funding for energy-saving programs

Tools and Guidance

Hu, J., F. Kahri, Q. Yan, and X. Wang, 2012. “The impact of China’s differential electricity pricing policy on power sector and CO₂ emissions.” *Energy Policy* 45, 412-419.

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Moskovitz, D., Lin, J., Weston, F., Zhou, F, Liu, S., Hu, Z., Bai, Jianhua, and Yu, C., 2007. *Part A Final Report TA 4706-PRC: Energy Conservation and Resource Management Project*. Asian Development Bank, Manila.

Moskovitz, D., 2008. *Climate Change Policy Options for China's Power Sector*. Regulatory Assistance Project.

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I11: Energy Management Standards

Description

Energy management standards are used to institutionalize continuous improvement in energy efficiency within industrial facilities. These standards are typically based on the “plan-do-check-act” approach with the goal of providing guidance to industrial facility managers related to how to structure their operations in a manner that continually identifies, adopts, and documents energy-efficiency opportunities.

Energy management standards have been adopted in China, Denmark, Ireland, Japan, South Korea, the Netherlands, Sweden, Thailand, and the United States. While most of these standards include key elements such as establishing a management-appointed energy coordinator and developing an energy management plan, they are not uniform in their adoption of elements such as external validation or certification of claimed energy savings or the intervals for re-evaluating performance targets (Price and McKane, 2009). To provide more standardized guidance for energy management systems, the International Standardization Organization (ISO) initiated “ISO 50001: Energy management systems – Requirements with guidance for use” in 2008. This standard was published in 2011 (Piñero, 2009) and aims to:

- Assist organizations in making better use of their existing energy-consuming assets
- Offer guidance on benchmarking, measuring, documenting, and reporting energy intensity improvements and their projected impact on reductions in GHG emissions
- Create transparency and facilitate communication on the management of energy resources
- Promote energy management best practices and reinforce good energy management behaviors
- Assist facilities in evaluating and prioritizing the implementation of new energy-efficient technologies
- Provide a framework for promoting energy efficiency throughout the supply chain
- Facilitate energy management improvements in the context of GHG emission reduction projects
- Allow integration with other organization management systems (environment, health and safety)

Energy management standards are also coupled with energy manager training, as energy managers play a critical role in implementing energy management standards and integrating energy management practices into daily operations. For more information on energy manager training, please see policy “Energy Manager Training”.

Implementation Strategies and Challenges

Implementation Activity	Description
Provide technical assistance	The government identifies a lead institute or entity and allocates staff and funding to assist enterprises in understanding and adopting energy management standards. The institute or entity could also provide complimentary technical assistance, guidance, and training courses on benchmarking, measuring, documenting, and reporting energy intensity improvements, as well as implementing energy efficiency technologies.
Form an energy team	Enterprises form a dedicated energy team, appoint an energy director, and institute an energy policy, as key steps for implementing an energy management standard.
Monitor, evaluate, and disseminate	The designated institution should monitor the implementation of energy management standards in enterprises, evaluate associated energy savings performance, and make evaluation reports publicly available.

Implementation challenges could include institutionalizing and internalizing energy management systems for continuous improvements in enterprises. The key elements of energy management systems can also be linked to other business management systems, to avoid putting additional burdens on enterprises. Local governments can assist the enterprises with guidance documents, tools, training, and capacity building to facilitate the implementation. In addition, for proper evaluation of the impacts and outcomes of the energy management systems, measures or methods should be developed to identify appropriate indicators (IEA, 2012).

Monitoring Metrics

Monitoring metrics for energy management standards include:

- Number of enterprises that implement certified energy management systems in adherence with energy management standards

Case Studies

Sustainable Energy Ireland, Ireland

http://www.seai.ie/Your_Business/Large_Energy_Users/Resources/Energy_Management_Systems/

Sustainable Energy Ireland (SEI) implements an industrial energy agreement program based on the Irish Energy Management Standard, IS 393. The SEI Energy Agreements focus on large, energy-intensive industrial enterprises, with an annual energy costs of €2 million (16.1 million RMB) or more.

Participating firms are required to become certified in the Energy Management Standard which established structures and processes designed to bring significant savings in energy, associated costs, and greenhouse gas emissions. The Energy Management Standard requires that senior management be directly involved in establishing and supporting energy-saving and emissions reduction policies. An energy review to gain an understanding of baseline energy use in the organization is used to prioritize efforts to reduce energy use. The Energy Management Standard is similar to and compatible with the Environmental Management System Standard ISO 14001.

The Irish energy management standard IS 393 is one of the first energy management standards in the world. As of 2008, 28 companies were certified under IS393 (1 in 2006, 9 in 2007 and 18 in 2008). The members that are in the Irish Energy Agreements Program reported energy efficiency gains of 8% in 2007 and 6% in 2008 (see the above link). IS 393 provided experiences and lessons learned in implementing energy management standards, and led the way to an European energy management standard EN 16001, which was published in August 2009. The international energy management standard – ISO 50001 was published by the International Standards Organization (ISO) in June 2011. In the process of standards development, SEI also played an important role in providing a guidance standard for implementation and maintenance of an energy management standard. By 2010, 45 companies in 65 sites were formally certified to EN 16001, and are currently implementing the new ISO 50001 standard. At present, a subset group of companies in the Irish Energy Agreements Program is committed to ISO 50001 implementation.

Long-Term Agreements, Netherlands

http://www.seai.ie/Your_Business/Large_Industry_Energy_Network/LIEN_Events/Ronald_Vermeeren.pdf

In The Netherlands, guidance for establishing an Energy Management System based on the ISO 14001 standard for environmental management systems was developed in support of the Long-Term Agreements (LTAs). Companies that joined the second phase of the LTAs (LTA2) have an obligation to implement an energy management system within two years. The requirements are explained and outlined in *Structural Attention for Energy Efficiency by Energy Management. The Energy Management System Specification with Guidance for Use* and the *Energy Management Checklist* which provides a means to verify which requirements have been fulfilled and which require improvement. From 2001 to 2007, average energy efficiency of LTA members improved by 2.4% compared to 1% for non-LTA members.

ENERGY STAR for Industry Program, U.S.

http://www.energystar.gov/index.cfm?c=industry.bus_industry

The U.S Environmental Protection Agency's Energy Star for Industry program provides *Guidelines for Energy Management* with detailed information on how to undertake the following steps: 1) Make Commitment, 2) Assess Performance, 3) Set Goals, 4) Create Action Plan, 5) Implement Action Plan, 6) Evaluate Progress, and 7) Recognize Achievements. EPA has also developed an Energy Program

Assessment Matrix to help organizations and energy managers compare their energy management practices to those outlined in the Guidelines and a Facility Energy Assessment Matrix to help energy managers evaluate management at their facilities.

Experience with implementation of energy management standards at two facilities in the U.S. indicated cost-effective savings of 5% and 14%, respectively. It is estimated that use of energy management standards will result in approximately 10% cost-effective annual energy savings over 15 years (McKane, 2010).

Attributes

- Carbon Savings Potential

Medium

Research reports have indicated that implementing energy management standards and adopting energy management practices could save industrial enterprises 10% to 30% of their total energy use (IEA, 2012). Companies that implemented energy management systems reported significant savings as well – for example, Dow Chemical achieved 22% reduction in energy intensity between 1994 and 2005; UTC reduced 12% energy intensity between 2006 and 2010; Toyota has reduced 23% of its energy intensity since 2002; and InterfaceFLOR has achieved 35% improvement in energy intensity from 1994 to 2004 (Scheihing, 2009).

Depending on the number of enterprises that implement the energy savings standards, and assuming an average energy savings, it is estimated the energy-savings potential for local cities is medium.

- First Cost to Government

Medium

It is reported that installing an Enterprise Energy Management (EEM) system could cost about 126,000 USD (approximately 800,000 RMB)⁴² (Motegi and Waston, n.d.). Depending on the number of installed systems, the costs of adopting the systems would be medium. There are other cost components as well, such as initial costs for training, capacity building, and incorporating energy management standards into existing business operations.

- Speed of Implementation

< 1 year

- Co-Benefits

Reduced carbon dioxide emissions, reduced water use and waste, improved air quality, enhanced public health, increased productivity, energy and financial savings

Tools and Guidance

Lawrence Berkley National Laboratory. *Energy management standards and industrial energy efficiency*. Available at: <http://industrial-energy.lbl.gov/node/94>.

⁴² Based on 2012 US dollars to RMB average exchange rate: 1 USD = 6.3033 RMB (<http://www.oanda.com/currency/historical-rates/>)

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<http://www1.eere.energy.gov/energymanagement/>.

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I12: Energy Manager Training

Description

Energy management is a systematic use of management and technology to improve an organization's energy performance. As defined under the *ISO 50001 Energy Management Standard (2011)* by the International Standard Organization, energy management system is a "set of interrelated or interacting elements to establish an energy policy and energy objectives, and processes and procedures to achieve those objectives." Energy management is a key means for industrial enterprises to control energy costs and to ensure compliance with energy efficiency legislation. An energy manager is the person responsible for implementing the energy management plan or energy strategy of industrial enterprises. Many industrial facilities do not have a designated energy manager. Therefore, energy manager training, provided by the government or an industrial association or other qualified organization, is needed for enterprises to ensure that the principle of continuous energy management is realized in their facilities. International countries that have established its own national energy management standards, such as Denmark, Ireland, and The Netherlands, have all provided training on standard compliance and offer technical assistance on energy management (McKane et al., 2007).

Energy manager training is essential for the implementation of energy management standards (see policy "Energy Management Standards"), and energy managers play an important role in achieving the plant's targets under an industrial energy plan ("Industrial Energy Plan") or in achieving any stretch targets ("Stretch Targets for Industry") the plant sets.

China has published its national energy management standard (GB/T 23331: Management System for Energy – Requirements) in 2009. After the ISO 50001 was published in 2011, the national standard was revised as the Management System for Energy – Requirements and User Guidance in 2012, in order to be compatible with the international standard.

Implementation Strategies and Challenges

Implementation Activity	Description
Identify implementing organizations	The local government identifies an existing governmental agency, a local research institution, or a third party to implement the policy. The local government could also establish a new commission to lead the policy as well.
Establish an energy manager training program	The designated implementing organization establishes an energy manager training program, identifying the scope, targeted audiences/sectors, cost-sharing mechanisms, and processes for participation. Local governments identify or designate governmental agencies or third-party organizations to manage and administer the program.
Develop training courses	The implementing organization can designate research institutes, universities, or other organizations to work closely with industrial associations to develop training

	materials. The length and depth of the training should also be taken into consideration, based on local needs and funding situations.
Establish certification process	A rigorous certification process should be established to assure the quality of the trained energy managers. Certification could be based on examinations, on-site testing, or a combination of both. Certification could be annually or at regular intervals.
Implement, monitor, and evaluate	The implementing organization implements the program, and monitors the performance of the certified energy managers by evaluating or randomly checking the energy efficiency levels at their working facilities.
Information dissemination	Lists of certified energy managers, information on energy manager training workshops, case studies on best practices, and guidebooks on energy management should be disseminated through the program's website.

Some implementation challenges could include providing quality control and assurance of the trained energy managers; providing specific training tailored to specific industrial sectors may require higher amounts of funding and resources; and establishing and maintaining a rigorous certification and accreditation process for energy manager training.

Monitoring Metrics

Monitoring metrics for energy manager training include:

- Number of training workshops conducted
- Number of participating managers
- Percentage of industrial enterprises that have received energy manager trainings
- Implementation rates of energy efficiency measures
- Total investment for implementing energy efficiency measures
- Improved energy efficiency
- Annual energy savings and CO₂ emission reductions

Case Studies

Federal Energy Management Program, U.S. Department of Energy

<http://www1.eere.energy.gov/femp/>

The U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP) provides services, tools, and expertise to Federal agencies to help them achieve their legislated and executive-ordered energy, greenhouse gas, and water goals. FEMP also trains federal agency managers on the latest energy requirements, best practices, and technologies.

FEMP provides free webcast trainings and other training materials for energy managers. The budget of FEMP in 2010 was \$32.3 million (200.7 million RMB).

Certified Energy Manager Training and Certification Program, Canada

<http://www.cietcanada.com/training-and-certification/cem/>

The Canadian Institute for Energy Training (CIET) is the exclusive Authorized Training Provider of the Association of Energy Engineers (AEE) for the delivery of the Certified Energy Manager (CEM) training and certification program in Canada. This special in-depth five-day seminar is ideal for professionals who seek a more detailed program of instruction covering the technical, economic, and regulatory aspects of effective energy management. The program offers a comprehensive learning and problem-solving forum for those who want a broader understanding of the latest energy cost reduction techniques and strategies, and who want to achieve the CEM designation as recognition of their expertise.

Energy Management Training under Ireland's Energy Agreements Programme (EAP)

http://www.seai.ie/Your_Business/Large_Energy_Users/Energy_Agreements_Programme/

Ireland's voluntary agreements, known as the Energy Agreements Programme (EAP), run by the Sustainable Energy Authority of Ireland (SEAI), aim to stimulate energy efficiency activity within the largest consumers of energy in Ireland above and beyond business-as-usual. While the EAP is voluntary, participating companies are required to implement the International Energy Management Systems Standard ISO 50001. During the initial three-year period of the agreement, SEAI provides technical support, networking assistance and financial support (IIP, 2013). The governmental agency also provides on-going and repeated training courses to the companies that joined the EAP, and to top management, energy managers, and engineers of the companies. Workshops on special topics on energy management are offered to the EAP members as well.

Energy Managers Training in Japan

<http://www.asiaeec-col.eccj.or.jp/aebf/pdf/07.pdf>

Under the *Amended 2005 Energy Conservation Law of Japan*, energy management officers are certified through energy managers training. To be qualified for their positions, energy managers are required to attend the training once every three years to continuously improve their knowledge. The training workshops usually cover topics such as energy management, energy efficiency policies and regulations, and the techniques and practices of energy management. The Energy Conservation Center of Japan, as the designated organization by the Law, provides trainings as well as national examinations for qualifying energy managers (ECCJ, 2006).

Energy Managers Training in India

http://www.energymanagertraining.com/new_index.php

Under India's *Energy Conservation Act of 2001*, which were amended in 2010, all of the designated consumers are required to conduct energy audits that are carried out by an accredited energy auditor and they are required to designate or appoint an energy manager. The government has specified specific energy consumption thresholds for energy-intensive industries and other large consumers to be "Designated Consumers". To be qualified and accredited as energy managers, applicants are required to take energy manager training and pass the energy manager examinations that are hosted and organized by the government. Information regarding energy management, case studies, training courses, guidebooks, and sector-specific information is also available through the government website portal (Energy Manager Training of India, 2013).

Energy Managers Training in Shandong Province, China

In 2008, Shandong Provincial Government published a provincial standard on energy management systems (DB/T 1013 Energy Management System – Requirements). This standard was piloted in eight provincial industrial enterprises since June 2008. In 2009, the Shandong government issued *Guidelines on Building Energy Management System in Enterprises of Shandong Province*, published *Industrial Enterprises Energy Management System*, and established consulting and evaluation expert teams. In the 12th Five-Year Plan, to support the national Top 10,000 Program, Shandong Province has continued providing training for energy managers on energy management and assisting industrial enterprises to establish energy management systems.

Attributes

- Carbon Savings Potential
Medium
It is estimated that the aggregated results of energy manager training are medium, if a large share of the industrial enterprises in the local cities take the training and apply the knowledge into daily operational practices.
- First Cost to Government
Medium
Once the program has been established, with coursework and training materials developed, the cost for the government to run and manage the energy manager training program is estimated to be low, especially when the training program is cost-shared, e.g., participants pay registration or certification fees.
- Speed of Implementation
<1 year
- Co-Benefits

Improved energy efficiency, reduced carbon dioxide and other air pollutants emissions, increased productivity, and energy savings

Tools and Guidance

U.S. Department of Energy. *Resources for industrial facilities*. Available at: http://www1.eere.energy.gov/femp/program/industrial_facilities_resources.html.

U.S. Department of Energy. *Energy management guidance*. Save Energy Now. Available at: <http://www1.eere.energy.gov/femp/regulations/guidance.html>.

Doty, S. and W. C. Turner. *Energy Management Handbook (7th Edition)*. Available at: https://www.aeeprograms.com/store/detail.cfm?id=631&category_id=6.

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Energy Conservation Center of Japan (ECCJ), 2006. *Act Concerning the Rational Use of Energy (2005 Revised Energy Conservation Act)*. Available at: <http://www.eccj.or.jp/law/e-law.html>

Institute for Industrial Productivity (IIP). *Fact sheet: Ireland's energy agreements programme (EAP)*. Access on Mar.24, 2013 at: http://www.iipnetwork.org/sites/iipnetwork.org/files/file_attachments/resources/IIP_Ireland_Factsheet.pdf.

McKane, A., R. Williams, W. Perry, and T. Li, 2007. *Setting the Standard for Industrial Energy Efficiency*. Lawrence Berkeley National Laboratory. Berkeley, CA. Available at: <http://industrial-energy.lbl.gov/node/399>

I13: Recycling Economy and By-product Synergy Activities

Description

Inspired by Japanese and German Recycling Economy Laws, China formed a Circular Economy (CE) initiative that is an important strategy for the economic and social development. In 2008, the Standing Committee of the 11th National People's Congress (NPC) formalized aspects of the circular economy concept in the *Circular Economy Promotion Law*. According to the law, the term "circular economy" is a generic term for the reducing, reusing, and recycling (3Rs) activities conducted in the process of production, circulation, and consumption.⁴³ By-product synergy activities between industrial enterprises are important components to achieve circular economy. The circular economy approach to resource-use efficiency integrates cleaner production and industrial ecology in a broader system encompassing industrial firms, networks or chains of firms, eco-industrial parks, and regional infrastructure to support resource optimization. State owned and private enterprises, government and private infrastructure, and consumers all have a role in achieving the circular economy. The three basic levels of action are (Indigo Development, 2009):

- At the individual firm level, managers must seek much higher efficiency through the three Rs of the circular economy: reduce consumption of resources and emissions of pollutants and waste, reuse resources, and recycle by-products.
- The second level is to reuse and recycle resources within industrial parks and clustered or chained industries, so that resources will circulate fully in the local production system.
- The third level is to integrate different production and consumption systems in a region so the resources circulate among industries and urban systems. This level requires the development of municipal or regional by-product collection, storage, processing, and distribution systems.

Circular economy and by-product synergy activities can take place at the district-level, the city-wide level, or they can be integrated into the low carbon industrial parks. Circular economy and by-product synergy activities are one of the means to achieve the goals set by the low-carbon industrial parks. For more information on low-carbon industrial parks, please refer to policy "Low-carbon Industrial Parks".

⁴³ The National Development and Reform Commission (NDRC) defines circular economy as: "CE may be interlinked manufacturing and service businesses seeking the enhancement of economy and environmental performance through collaboration in managing environmental and resource issues." "CE concept is the exchange of materials where on facility's waste, including energy, water, and materials – as well as information – are another facility's inputs. By working together, the community of businesses seeks a collective benefit that is larger than the sum of individual benefits each enterprise, industry and community would realize if it intended to optimize its performance on an individual basis." (Source: Pinter, 2006)

Implementation Strategies and Challenges

Implementation Activity	Description
Identify implementing organizations	The local government identifies an existing governmental agency, local research institution, third party, or establishes a new commission to implement the policy. Appropriate funding should be allocated.
Evaluate the potential and feasibility of circular economy and byproduct synergy activities	The implementing organization evaluates the potential and feasibility of conducting circular economy activities, in terms of the current status of resource utilization, financial availability, and expertise. To assess the potential of by-product synergies, research activities should be conducted to develop an inventory of each enterprise's waste and input needs. The inventory list should also be kept updated over time.
Establish the program	The implementing organization coordinates closely with participating industrial enterprises, industrial associations and other research institutes to establish a program for circular economy and byproduct synergy activities, including program scope, program length, required funding, program targets, and measuring metrics.
Develop an industrial energy baseline	The implementing organization needs to have a better understanding of the types of industrial enterprises in the area, including their energy use, types of products manufactured, as well as current situation of reuse, recycle, and recovery of resources and materials. Efforts to establish energy baselines could include activities such as gathering data, establish base lines, identify energy audits and benchmarking studies.
Create an action plan	The implementing organization works with the industries to design the process of implementing circular economy activities and to develop an action plan with specific timelines and identified priority projects.
Assist to identify industrial byproduct or symbiotic opportunities among industrial companies	The implementing organization assists industrial companies in identifying opportunities to reuse, recycle, and recover resources and materials within their companies, or among different industrial companies.
Track results	It is important to establish an energy measurement and reporting system to track results.
Review, evaluate, and update	The team should review and evaluate the actual annual energy and material savings and update its annual circular economy plan.
Information dissemination	The implementing organization disseminates best practices, case studies, and lessons learned to other industrial sectors or local districts that have not adopt circular economy and byproduct synergy activities.

Implementation challenges that local governments may face include defining proper boundaries and methodologies for analysis based on local conditions and industrial production; lack of data for opportunity analysis, and difficulty of defining commonly accepted and transparent indicators.

Monitoring Metrics

Monitoring metrics for circular economy activities include:

- Number of byproduct/symbiotic exchanges (in energy, water, material uses)
- Recycling and reuse percentages of material and water
- Annual energy savings and CO₂ emission and other air pollutants emissions reduction

Case Studies

Asahi Brewery, Japan

<http://www.gdrc.org/sustdev/concepts/25-zero.html>

In November 1996, Asahi Breweries attained the goal of zero emissions at its plant in Ibaraki, Japan (close to Tokyo). In November 1998, the company attained the zero-emissions goal at all of its plants. For years, Asahi had been making an effort to reuse industrial wastes, including using excess yeast in pharmaceuticals and foods processing wastes at its pharmaceutical and food plant. Through these efforts it achieved an overall trash recycling rate of 98.5%. In order to attain the goal of zero emissions, it conducted studies to identify what plant wastes were not yet being recycled and then sought a specialist to undertake the recycling of these wastes, by type of raw material, and contracted this work to them. Asahi attained the goal of zero emissions by making the sorting process as thorough as possible by having wastes collected by type.

Kalundborg Eco-Industrial Park, Denmark

<http://www.symbiosis.dk/en>

The Kalundborg Eco-Industrial Park was established in 1996 and consists of a group of industries, including the municipality of Kalundborg, a power company, an oil refinery, a fertilizer industry, and several farms. In the Kalundborg Symbiosis Project, public and private enterprises buy and sell waste products from industrial production in a closed cycle. The residual products traded can include steam, dust, gases, heat, slurry or any other waste product that can be physically transported from one enterprise to another. A residual product originating from one enterprise becomes the raw material of another enterprise, benefiting both the economy and the environment. The annual CO₂ emissions are reduced by 240,000 tonnes while 3 million m³ of water is saved through recycling and reuse. In addition, 30,000 tonnes of straw is converted to 5.4 million liters of ethanol, 70% of soy protein in traditional feed mix for 800,000 pigs is replaced by 150,000 tonnes of yeast, and import of natural gypsum (CaSO₄) is

replaced by the recycling of 150,000 tonnes of gypsum from desulphurization of flue gas (SO₂). The circular economy represents a net material cost saving opportunity of \$340-380 billion (2.11-2.36 trillion RMB) at EU level for a “transition scenario” and \$520-630 billion (3.23-3.91 trillion RMB) for an “advanced level”, in both cases net of the materials used in reverse-cycle activities (Ellen MacArthur Foundation, 2012).

Kawasaki Eco-town, Japan

http://www.unep.org/ietc/Portals/136/Publications/Waste%20Management/Eco_Towns_in_Japan.pdf

Kawasaki Eco-Town was approved in 1997 as one of the first Eco-Towns in Japan. Mutual use of by-products and production wastes as raw materials have been promoted in the newly-built recycling plants and existing companies in Kawasaki Eco-Town. Showa-Denko (a chemical company) provides ammonia produced in the manufacturing process for other nearby enterprises. Corelex Co. Ltd. (a paper company) provides the incinerated ashes generated in the process of manufacturing toilet paper from used papers for cement companies as cement raw material. Corelex also uses the surplus electricity of JFE (a steel company) and the recycled water treated in a municipal wastewater treatment plant. Nihon Yakin uses the materials generated by JFE in the electric appliance recycling process as raw material for special alloy.

Attributes

- Carbon Savings Potential
Medium
Tianjin Iron & Steel Group Co. has achieved 100% recycling and reuse of solid wastes including iron slag, steel slag, iron dust, iron oxide skin and environmental dust, and 98% recycling and reuse of water. During the 11th FYP, the enterprise exceeded its energy-saving target of an annual energy intensity reduction of 7%.
The efficiency gains for recycling vary widely depending on materials: the recycling of aluminum during the manufacturing process results in an energy saving of 96 percent, while that for glass is 21%, newsprint is 45%, plastic is 88%, and iron and steel is over 50% (UNEP, 2008).
- First Cost to Government
Medium
The cost for government to develop a circular economy plan and to implement the plan in designated areas and industries is estimated to be medium. More costs are expected to be borne by the industrial companies, unless local governments provide subsidies or incentives for industrial companies to invest in circular economy activities.
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced carbon dioxide emissions, reduced water and material use, increased productivity, cleaner production, energy or financial savings, job creation, improved quality of life

Tools and Guidance

United Nations Environment Programme (UNEP). 2006. "Circular economy: an alternative model for economic development." Available at: <http://www.unep.fr/scp/nap/circular/pdf/prodev-summary.pdf>.

World Bank. 2009. "Developing a circular economy in China: highlights and recommendations." Available at: http://www-wds.worldbank.org/external/default/WDSPContentServer/WDSP/IB/2009/07/15/000333037_20090715021249/Rendered/PDF/489170REPLACEM10BOX338934B01PUBLIC1.pdf.

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Pinter, L. 2006. "International Experience in Establishing Indicators for the Circular Economy and Considerations for China." Report for the Environment and Social Development Sector Unit, East Asia and Pacific Region, the World Bank. International Institute for Sustainable Development. Available at: http://www.iisd.org/pdf/2006/measure_circular_economy_china.pdf

United Nations Environmental Programme (UNEP). 2008. *Green Jobs: toward decent work in a sustainable, low-carbon world*. http://www.unep.org/PDF/UNEPGreenjobs_report08.pdf

I14: Low-carbon Industrial Parks

Description

Development of low-carbon industrial parks is an important strategy for achieving low-carbon city development in China. In general, low-carbon industrial parks are a co-located community of low-carbon manufacturing and service business located together to achieve circular economy, high energy efficiency, and environmental benefits. The recently published *Guide for Low Carbon Industrial Development Zones* by the Institute for Sustainable Communities notes that a low carbon industrial zone “should produce the least amount of greenhouse gas emissions while still maximizing social and economic outputs in order to achieve social, economic, and environmental sustainability”. Efficient use of land, resources, and energy should be realized in the low carbon industrial zones/parks. Member enterprises seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues. By working together, the co-located community of businesses seeks a collective economic and environmental benefit that is greater than the sum of individual benefits each enterprise would realize by only optimizing its individual performance.

A number of energy-efficiency and low-carbon activities can be conducted in low-carbon industrial parks, such as circular economy and by-product synergy activities, which are described under policy “Recycling Economy and By-product Synergy Activities”. Fuel switching (see policy “Fuel-switching”) and other in-house energy-efficiency projects (such as policy “Energy Audit/Assessments” on energy audits and policy “Energy Management Standards” on implementing energy management standards) can also be considered for achieving the targets of the low-carbon industrial parks.

Implementation Strategies and Challenges

Implementation Activity	Description
Identify implementing organizations	The local government identifies an existing governmental agency, a local research institution, or a third party to implement the policy. The local government could also establish a new commission to lead the policy as well.
Assess resources	It is necessary to develop an inventory of resources available at local, state and national levels at the early stage of establishing a low-carbon industrial park. Resources may include staff, organizations, and sources of information/data, and funding that can support the project.
Establish a program	The next step is integrating the input obtained into a compelling program of a low-carbon industrial park development. A clearly articulated vision and mission with respect to environment, social, and economic performance will guide daily practice at all levels of the enterprise.
Make a plan	The plan for the development of the low-carbon industrial park should include goals, site selection,

	management and operation of the industrial park, financial funding, environmental standards, and policy and regulations.
Implement the project	Implement the project with funding secured within the plan and relevant programs.
Track results	It is important to establish an energy and material measurement and reporting system to track results.
Review, evaluate, and update	The implementing organization should review and evaluate the actual annual energy, water and material savings, pollution reductions, and update its annual plan.
Information dissemination	The implementing organization disseminates best practices, case studies, and lessons learned to other industrial parks, or other cities.

Some of the implementing challenges for local governments include lack of appropriate incentives to encourage enterprises; lack of comprehensive, indicative, and trackable indicators for low-carbon industrial parks; lack of data collecting systems; lack of staffs, methods and standards to conduct evaluation assessments.

Monitoring Metrics

Monitoring metrics for low-carbon industrial parks include:

- Annual energy savings
- Recycling and reuse percentages of material and water
- Annual CO₂ emission reduction
- Annual air pollutant emissions reduction
- Improvement of energy intensity of key industrial products
- Improvement of carbon intensity
- Percentage of non-fossil fuel in total energy mix
- Percentage of enterprises that have adopted the Energy Management System
- Percentage of certified green buildings in the industrial parks
- Share of green transportation

Case Studies

Kalundborg Eco-Industrial Park, Denmark

<http://www.symbiosis.dk/en>

The Kalundborg Eco-Industrial Park was established in 1996 and consists of a group of industries. In Kalundborg Symbiosis, the Asnæs power company supplies residual steam to the Statoil refinery and, in exchange, receives refinery gas that used to be flared as waste. The power plant burns the refinery gas

to generate electricity and steam. It sends excess steam to a fish farm that it operates, to a district heating system serving 3,500 homes, and to the Novo Nordisk plant. Sludge from the fish farm and pharmaceutical processes becomes fertilizer for nearby farms. The power plant sends fly ash to a cement company, while gypsum produced by the power plant's desulfurization process goes to a company that produces gypsum wallboard. Finally, the Statoil refinery removes sulfur from its natural gas and sells it to Kemira, a sulfuric acid manufacturer. Annual CO₂ emissions are reduced by 240,000 tons, annual heat recovery is around 39,000 GJ, and 3 million m³ of water is saved through recycling and reuse (Jacobsen, 2006). In addition, 30,000 tons of straw is converted to 5.4 million liters of ethanol, 70% of soy protein in traditional feed mix for 800,000 pigs is replaced by 150,000 tons of yeast, and import of natural gypsum (CaSO₄) is replaced by the recycling of 150,000 tons of gypsum from desulphurization of flue gas (SO₂). It is estimate that a \$60 million (372.7 million RMB) initial investment of the Kalundborg eco-industrial park has generated approximately \$120 million (745.5 million RMB) additional revenue over a five-year period.

The Kawasaki Zero Emission Industrial Park, Japan

http://www.unep.org/ietc/Portals/136/Publications/Waste%20Management/Eco_Towns_in_Japan.pdf

The Kawasaki Eco-Town project aims to create a zero-emission industrial park in which the activities of all those concerned will be coordinated in an environmentally friendly manner. The zero-emission industrial park will be a resource-recycling industrial park. The individual industrial firms within the industrial park not only will reduce their own emissions but also will effectively utilize or recycle into usable resources the emissions from other facilities located there. There were 15 enterprises in the complex (metal-processing, paper, plating, forging, and stamping enterprises) as of October 2004. Together they operate the Kawasaki Zero Emission Industrial Complex Association. Conditions applied to enterprises in the complex are: (1) each participating enterprise should have its own basic environmental policy and agree to the goal of the complex, (2) each enterprise should challenge a higher goal (zero emission) than just emission standards in reducing its environmental impacts, (3) each enterprise should deal with the issue efficiently through linkage with other enterprises that constitute the complex, and (4) each enterprise should internalize environmental loading factors within a process of manufacturing as much as possible through collaboration among enterprises. About JPY 25 Billion (1.92 billion RMB)⁴⁴ in total has been provided as a subsidy from the national government and Kawasaki city (Global Environment Centre Foundation, 2005). It is one of the leading areas where recycling facilities are clustered and by-product exchange is conducted among business entities.

⁴⁴ Based on the average exchange rate between 1996 and 2004: <http://www.oanda.com/currency/historical-rates/>.

Bruce Eco-Industrial Park, Canada

<http://www.bruce-eco.com/>

The Bruce Eco-park is one of the world's largest steam and electricity generating complexes and has operated successfully for more than 30 years. It is organized around Ontario Hydro's nuclear power station to take advantage of its waste heat and steam generation capacity. At the present there are six reactor units in operation, which produce approximately 5,000 megawatts of electricity. Steam is provided via a 24 inch (600 mm) pipeline which delivers 250,000 lbs/hr of steam to the Eco-industrial Park (Bruce ECO Landbank, 2006). The industries that have co-located use this steam for processes, such as dehydration, concentration, distillation, hydrolysis and space heating. Bruce ECO Landbank is developing into a community of processing, manufacturing, and service businesses/facilities located together on a common integrated and interlinked property in accordance with the Eco-Industrial Park principles. Member businesses seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues. The main goal of the Bruce ECO Landbank is to improve the economic performance of the participating companies while minimizing their environmental impacts, by establishing a system where the by-product of one industry/process is the raw material of another neighboring industry/process, resulting in lower pollution and environmental impact. Components of Bruce ECO Landbank include "green" design of the industrial park infrastructure and facilities, cleaner production methods, pollution prevention systems, energy efficiency, and inter-company partnerships.

Attributes

- Carbon Savings Potential
Medium
It is expected that the energy-savings and carbon dioxide emission reduction potential could be at the medium level for developing low carbon industrial parks, which have implemented energy-saving, emission reduction, circular-economy, and eco-development measures. The low carbon industrial parks also provide valuable opportunities for industries and businesses to optimize and utilize materials and wastes more efficiently.
- First Cost to Government
Medium
Information and literature on the costs of developing a low-carbon industrial park is quite limited at this point. For the local governments, the main costs would include developing plans for low-carbon industrial park, implementing systems to track performance, conducting evaluation, and publicizing results.
- Speed of Implementation
>3 years
- Co-Benefits
Reduced carbon dioxide and other air pollutants emissions, reduced water and material use, increased productivity, increased employment opportunities, energy or financial savings

Tools and Guidance

Ayres, R., and L. Ayres. 2002. *A Handbook of Industrial Ecology*. Edward Elgar Publishing Limited, UK.
Available at: http://iepoi.uni-mb.si/samec/Handbook_Industrial_Ecology_2002.pdf.

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I15: Industrial Fuel-switching

Description

Many industrial applications or processes can use different fuels to produce steam or process heat. However, in reality the choice is often limited by the cost, availability, and environmental regulations related to the various fuel options. According to the Intergovernmental Panel on Climate Change's *Third Assessment Report*, the potential to reduce carbon intensity in industry through fuel switching is estimated in the range of 10 – 20% (IPCC, 2007).

One option for industries is to switch to lower carbon intensity fossil fuels, such as replacing coal with natural gas. Industries are increasingly turning to the use of wastes or waste materials in fuel switching projects. For example, a variety of industries are using methane from landfills as a boiler fuel (US EPA, 2005). Waste materials, such as tires, plastics, used oils and solvents and sewage sludge are being used in a growing number of industries. Rather than landfill or incinerating the wastes without heat recovery, the use of wastes or waste materials can provide energy and climate benefits from a life cycle perspective. Plastics have been used in the steel industry as alternative fuel and feedstock (Ziebek and Stanek, 2001), with net emissions reduction of 0.6 MtCO₂-eq/yr in Japan (Okazaki et al., 2004). Wastes have also been used as an alternative fuel in cement industry. Heidelberg Cement (2006) reported using 78% waste materials (tires, animal meal and grease, and sewage sludge) as fuel for one of its cement kilns. Non-fossil fuels have also been used as alternative fuels in the cement industry. For example, Indian cement companies are using agricultural wastes and sewage (Jain, 2005). Studies estimated that fuel switching in cement industry has a global CO₂ emissions reduction potential of 12% by 2020 (Humphreys and Mahasenan, 2002).

However, limitations of fuel switching still exist, such as the availability of alternative fuels and the need for careful control of airborne toxic materials from certain wastes or waste materials (IEA, 2006).

Fuel-switching could play an important role in achieving the targets of low-carbon industrial parks (see policy "Low-carbon Industrial Parks"). Fuel-switching projects will be more attractive financially to investors and industrial companies, if fiscal incentives are provided, such as loans ("Industrial Energy Efficiency Loans and Innovative Funds"), tax relief ("Tax Relief"), or under an energy or CO₂ tax ("Energy or CO₂ Taxes").

Implementation Strategies and Challenges

Implementation Activity	Description
Identify implementing organizations	The local government identifies an existing governmental agency, a local research institution, or a third party to implement the policy. The local government could also establish a new commission to lead the policy as well.
Assess the potential	The implementing organization needs to assess and identify possible options for fuel switching within local industries.

Implementing organizations establish the program	Based on the assessment, the implementing organization can establish a program, providing financial support and/or technical assistance to support industrial fuel switching.
Develop an action plan	The implementing organization can work with industries to develop an action plan, including setting goals, analyzing technical options and costs, and setting timelines for fuel switching.
Implement the plan	Enterprises implement fuel switching projects.
Track results	Enterprises establish an energy measurement and reporting system to track and report energy savings and carbon dioxide emission reductions from fuel switching.
Review, evaluate, and disseminate	The implementing organization reviews and evaluates the actual performance as well as emission reductions of these fuel-switching projects. The implementing organization disseminates best practices, case studies, or lessons learned to the public.

Some challenges to implement this recommendation include: cost of alternative fuels (such as natural gas, wastes, biomass and other renewables); lack of suitable alternative fuel sources and adequate transportation; lack of awareness of fuel switching opportunities for carbon dioxide emission reduction and energy savings; lack of data collecting, monitoring and reporting systems.

Monitoring Metrics

Monitoring metrics for fuel-switching include:

- Number of participating enterprises
- Annual amounts of fuel use by technology
- Annual CO₂ reductions by technology
- Total investments for fuel switching programs
- Increased or reduced fuel costs
- Increased or reduced operation and maintenance costs

Case Studies

LG Chem Naju Plant Fuel Switching Project, South Korea

http://eco2data.com/project/LG-Chem-Naju-plant-fuel-switching-project-51185#tab_projectGeneral

LG Chem currently produces octanol, plasticizers, and acrylic acid at Naju plant. Originally, Naju plant was founded as a fertilizer plant in 1962 and was modified in 1982 to allow production of octanol. Through subsequent modification and expansion of the plant, current production has reached 190,000 million tonnes (Mt)/year for octanol, 166,000 Mt/year for plasticizers and 26,000 Mt/year for acrylic acid. Steam, which is used in the production process of petrochemical products, is mainly produced in a boiler using bunker fuel oil C (Sulphur 0.5%). On average over the past 3 years, LG Chem has used

approximately 23,500 kilolitres of bunker fuel oil C annually for steam generation at Naju plant. In 2006, The Fuel Switching Project activity involved retrofitting the boilers to allow fuel switching from bunker fuel oil C to natural gas. The total investment of this project was \$861,000 (5.36 million RMB) with an annual reduction of 19,635 tonnes of CO₂.

Kafr El Dawar Project, Egypt

<http://www.ecomena.org/tag/fuel-switch-project/>

Located at the Egypt for Misr Fine Spinning & Weaving and Misr Beida Dyers factories in Kafr El Dawar near Alexandria, this fuel switching project is a Clean Development Mechanism (CDM) project from the Middle East and North Africa region registered under the Kyoto Protocol. The Kafr El Dawar CDM project helps reduce CO₂ emissions through switching from higher carbon intensity fuel such as heavy fuel oil (HFO) to natural gas, a lower carbon intensity fossil fuel, contributing to Egypt's goals in sustainable development. It has also significantly mitigated atmospheric emissions of pollutants while improving air quality in the region. The replacement of HFO with natural gas is expected to reduce approximately 45,000 metric tonnes of CO₂ equivalent per year.

Graneros Plant Fuel Switching Project, Chile

<http://cdm.unfccc.int/Projects/DB/DNV-CUK1100697197.04/view>

The Graneros plant produces cereals, coffee, sugar, and other ingredients. The fuel switching project that started in 2004 aimed to reduce GHG emissions through replacing the use of the coal and other fossil fuels by natural gas, funded through the sale of carbon credits in the context of the Clean Development Mechanism (CDM) of the Kyoto Protocol. Before fuel switching, the consumption of coal was 11,400 t/year in the Graneros plant. The project is estimated to reduce 284,400 tonnes of CO₂ equivalent emissions over a 21-year time frame.

Attributes

- Carbon Savings Potential
High
It was estimated that replacing industrial fuel within fossil fuels (i.e. replacing coal with oil or natural gas) based on a comparison of average and lowest carbon intensities for eight industries could reduce CO₂ emissions by 10-20% (IPCC, 2007). Humphreys and Mahasenan (2002) estimated that global CO₂ emissions could be reduced by 12% through increased use of waste fuels.
- First Cost to Government
High
According to South Korea's experience from LG Chem Naju Plant Fuel Switching Project, the average investment cost per unit of CO₂ emission reduction was 273 RMB/tonne.
- Speed of Implementation
1-3 years

- Co-Benefits
Reduced carbon dioxide emissions, reduced pollutants, improved air quality, enhanced public health

Tools and Guidance

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Power and Heat Policy Recommendations

- P01: Minimum Performance Standards for Thermal Power Plants
- P02: Renewable Energy and Non-fossil Energy Targets or Quotas
- P03: District Heating Networking Maintenance and Upgrade Program
- P04: Transformer Upgrade Program
- P05: Time-based Electricity Pricing Schemes: Inclining Block Pricing and Time-of- Use Pricing
- P06: Load Curtailment Incentives/Demand Response/Curtailable Rates
- P07: Power Investment subsidies and tax incentives for Renewable Energy

P01: Minimum Efficiency or Emission Standards for Power Plants

Description

A minimum efficiency or emission standard for power plants specifies performance requirements that effectively limit the amount of energy consumed or specifies maximum emissions for generating one unit of electricity, usually measured in kilowatt hours (kWh) or megawatt hours (MWh). These standards are usually mandatory and imposed by a government energy-efficiency or environmental protection body. For countries with abundant coal, such as China and Australia, regulatory policies have been enacted to improve the efficiency of coal-fired power generation. In most cases, governments choose to set a direct efficiency, emissions, or technology standard for new or existing plants, but, in some cases, the government may mandate closure of small, inefficient coal-fired power plants.

Implementation Strategies and Challenges

In its 11th Five-Year Plan (2006 to 2010), China's State Council set a mandatory target of closure of 50 gigawatts (GW) of small, inefficient coal-fired power plants, to be replaced with larger, more efficient units. By July 2010, China had surpassed its original goal and closed a total of 70.7 GW of small-scale coal-fired power plants. To encourage the closure of small units, the policy provided incentives for enterprises with small units to undertake mergers, acquisitions, or restructuring before construction of large units would be approved (Lin et al. 2006).

To directly increase the process efficiency of coal-fired power plants, China's National Development and Reform Commission (NDRC) also requires that new power plants install super-critical or ultra-supercritical coal-fired units. The same policy can be enacted at a provincial or city level with higher generation efficiency standards to reflect local environmental and economic development targets.

In Australia, efficiency standards were introduced in 2000 to move fossil fuel generators toward best-practice energy efficiency. The 2004 standards set a legally binding, five-year efficiency standard of 42% net thermal efficiency for black coal (which has a higher heating value) and 31% net thermal efficiency for brown coal (which has a lower heating value) (IEA, 2010). In addition, beginning in 2011, all new power plants had to meet emission standards that reference a "best practice" technology-specific standard (Harris 2011).

In 2012, the U.S. Environmental Protection Agency proposed "new source performance standards" (NSPS) under the Clean Air Act to enforce an upper limit on carbon dioxide (CO₂) emitted by any new fossil-fuel-fired electricity generating unit. The limit is 1,000 pounds (lbs) CO₂/MWh, which is higher than the emissions of any natural-gas-fired power plant (800 lbs CO₂/MWh) but lower than the emissions of any current coal-fired power plant (1,800 lbs CO₂/MWh on average). Therefore, under the NSPS, any new coal-fired power plant would need to have equipment for capturing and storing at least half of the CO₂ it emits.

Monitoring Metrics

Depending on the exact type of regulation chosen, the government body in charge of energy efficiency or environmental protection would monitor at least one of the following quantities:

- Capacity of closed inefficient coal-fired power plants
- Emissions intensity of each power plant
- Energy efficiency of each power plant

The monitoring body would perform regular (e.g., annual) checks of existing power plants to ensure compliance with regulations and provide regulatory oversight (regarding mandated technology or emissions/efficiency standards) of any new power plants to be built.

Case Studies

State of California Emission Performance Standard, USA

http://www.energy.ca.gov/emission_standards/

On September 29, 2006, California's Governor signed into law Senate Bill 1368 (Perata, Chapter 598, Statutes of 2006), which limited long-term utility investment in baseload generation to power plants that meet a CO₂ emissions performance standard jointly established by the California Energy Commission and the California Public Utilities Commission. The Energy Commission regulations impose the standard for any baseload generation owned by, or under long-term contract to, public utilities at the level of 1,100 lbs CO₂ per MWh. This is intended to encourage the development of power plants that meet California's growing energy needs while minimizing greenhouse gas emissions. The law requires that publicly owned utilities post notices on long-term investments in new power plants on the Energy Commission website for public access.

Attributes

- Carbon Savings Potential
High
Savings potential depends on the amount of new coal-fired power capacity each year and the program targets. Shutting down 80 GW of inefficient small generators in the 11th Five-Year plan period saved 60 million tons of raw coal annually in China.
- First Cost to Government
Medium
\$0.10 - \$0.30/annualized kWh savings, maximum incentive for a 300-MW power plant is \$150,000
- Speed of Implementation
1 - 3 years
- Co-Benefits
Reduced CO₂ emissions, improved air quality, enhanced public health and safety

Tools and Guidance

IEA Clean Coal Center. [http:// www.iea-coal.org.uk](http://www.iea-coal.org.uk)

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P02: Renewable Energy and Non-fossil Energy Targets or Quotas

Description

Voluntary or mandatory renewable energy targets are often expressed as a share of total electricity production, installed capacity/absolute installed capacity by technology type, or primary or final energy consumption. Currently, 98 countries (including more than 40 developing countries) have renewable energy targets, with target years ranging from 2010 to 2020.

Implementation Strategies and Challenges

A widely used implementation option is a national renewable energy target expressed in terms of installed capacity or share of final energy consumption. After the European Union (EU) achieved its 2010 targets for wind, solar photovoltaic (PV), and heat pumps, a new baseline renewable target was set at 20% of energy consumed by 2020. Some member states, such as Finland and Sweden, have already met their 2020 goals, and others have adopted more aggressive targets ([Figure 1](#)). For example, Germany recently revised its Renewable Energy Sources Act of 2012 to require at least 35% of renewable energy in the electricity supply by 2020, 50% by 2030, and 80% by 2050 (Sustainable Business News 2011). China currently has technology-specific installed capacity targets for 2020 as well as a target of 15% of total primary energy consumption coming from non-fossil fuel sources (including nuclear) by 2020, and continuing to increase to 20% by 2030.

In addition to national renewable targets that signal support and provide certainty for expanding renewable energy industries, a country or state/province can set a minimum quota for renewable energy generation by utilities. This quota, sometimes known as a Renewable Portfolio Standard (RPS), is generally expressed as a minimum percentage of power generation sold or capacity installed that must be from renewable energy sources. By the end of 2010, nine countries had national quotas, including Australia, Italy, Japan, Poland, Romania, Sweden and the UK. Four countries have state or provincial-level quotas, including the U.S. where 38 states have some form of a mandatory or voluntary RPS (REN21 2011; DSIRE 2011). Among state RPSs, requirements are often broken down by technology type. Requirements that are set to require generation specifically from a single source such as solar PV are known as carve-outs and may be mandated in addition to an overall renewable energy requirement that could be met with any renewable energy technology.

In some countries, multiple utilities might be trying to meet the RPS target, in which case a system of Renewable Energy Certificates (RECs) is used to keep track of all renewable energy produced, purchased, and traded. For the regulatory body in charge of implementing the RPS, RECs are a method to monitor and verify compliance.

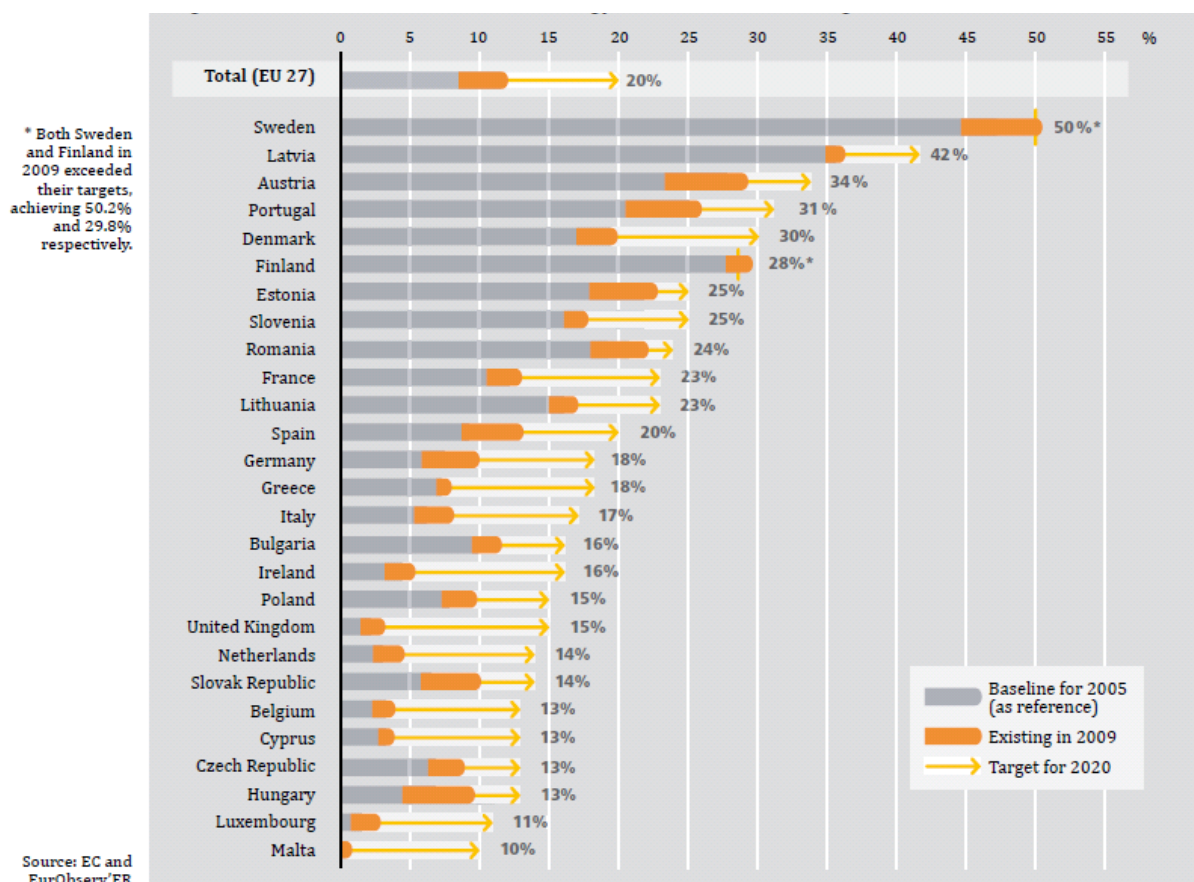


Figure 1. Renewable Share of Final Energy in EU States: 2005-2020

Monitoring Metrics

A regulatory body would be in charge of verifying that installed capacity or power generation targets were met, according to the implementation method chosen. In the case of a national target, the monitoring body would typically be an energy regulatory commission. For state RPSs in the U.S., a public utilities board or commission verifies the amount of electricity purchased from eligible renewable energy sources (often using RECs as described above or a similar system) as a proportion of total electricity purchased.

Case Studies

California Renewables Portfolio Standard, State of California, USA

<http://www.cpuc.ca.gov/PUC/energy/Renewables/index.htm>

California's RPS (established in 2002 by Senate Bill 1078, accelerated in 2006 by Senate Bill 107, and expanded in 2011 by Senate Bill 2) is one of the most ambitious renewable energy standards in the U.S. The RPS program requires investor-owned utilities, electric service providers, and community choice aggregators to obtain 33% of total procurement from eligible renewable energy resources by 2020.

Attributes

- Carbon Savings Potential
High
Depends on the annual newly installed renewable energy capacity and the energy generation from those sources
- First Cost to Government
Low
\$0.10 - \$0.30/annualized kilowatt hour (kWh) generation, maximum incentive for a kW of capacity
- Speed of Implementation
>3 years
- Co-Benefits
Reduced carbon emissions, improved air quality, enhanced public health and safety, and increased employment in renewable energy sector

Tools and Guidance

Renewable Energy Network 21. <http://www.ren21.net/>

Renewable Energy Costing Tool.

http://www.ethree.com/public_projects/renewable_energy_costing_tool.php

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P03: District Heating Networking Maintenance and Upgrade Program

Description

Many cities have established district heating networks whose primary plants (boilers) might be operating at low efficiency, or whose distribution system might have poor or no insulation, resulting in the loss of considerable thermal energy or water. Advances in materials, boiler designs, and alternative system configurations (for example, improved heat exchange) mean that high system efficiencies can be achieved today. A number of different methods have also been developed for detecting system leaks. Primary plant upgrades, leak detection and pipework repair/replacement, and improved insulation can result in more energy being delivered to end users of district heating system. This recommendation aims to develop maintenance and retrofit programs to upgrade district heating boiler plants, pumps, pipework, and insulation to reduce system resource (energy and water) use, operational costs, and carbon emissions.

Implementation Strategies and Challenges

District heating networks are usually city based. Cities have a number of options for increasing the efficiency of their district heating networks, including undertaking feasibility studies, making direct expenditures for system maintenance and repair, establishing legal or statutory requirements for efficiency, and contracting with energy service companies (ESCOs).

Implementation Activity	Description
Feasibility Study	The city engages a team including network planners, power and heat engineers, environmental specialists, and financial advisors to ensure that the feasibility study captures all pertinent information. The feasibility study determines technological and financial viability of a project, and procurement and policy options. It establishes the baseline city energy expenditure associated with power and heat supply and the efficiency of distribution through the district heating network(s). Technical ability, procurement methodology, incentives, and taxes should also be considered. Each option should be evaluated in light of the city's specific requirements and capabilities.
Direct expenditures & procurement	The city invests in maintenance and upgrades as necessary. The main expenditures in a replacement program are capital costs of the plant and of accessing buried pipework. The city can fund these items from its budget and recoup the investment over time through lower primary fuel costs.
Energy Services Company	The city contracts with an ESCO to manage the district heating network, including maintenance and repairs to ensure consistent, efficient supply to users. The benefit of this approach is that the city does not have to commit to significant financial investment or be responsible for project-related risks. There are a number of potential ESCO contract structures. It is recommended that the city explore the various advantages and disadvantages of each. See Jiamusi case study below for more details.
Legal or Statutory	The city enacts legislation or policy that requires minimum efficiency levels in both

	district heating generation and supply infrastructure. Efficiency levels should ensure that any replacement program is staggered, targeting worst-performing assets first.
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Monitoring Metrics

The city agency in charge of running or maintaining the district heating system should perform the following activities to ensure a successful outcome and monitoring:

- Establish baseline energy losses from pipework and pumps in kilowatt hours per year (kWh/yr)
- Establish baseline water losses (ton/yr) per year from pipework and pumps
- Establish a goal for reduced losses (kWh/yr) after potential network upgrades
- Compare actual and targeted performance

Case Studies

District Heating Network Pipe Maintenance, Seoul, Korea

DBDH, Direct Access to District Heating Technology "Seoul Metropolitan District Heating Network," <http://www.e-pages.dk/dbdh/12/>

Established in 1985 by a public corporation, Seoul's district heating network supplies 10,604 gigawatt hours energy intensity (GWh_t) of district heating and cooling to 832,000 households, commercial buildings, and public buildings. During its first five years of operation, the network experienced service interruptions because of construction failures. Pre-insulated pipe construction had only just been introduced in Korea when the network was built, and the skills of the construction team were inadequate to ensure a good quality installation. By the mid-2000s, 300 kilometers of pre-insulated pipelines (20% of the total pipeline length) were approximately 20 years old, and investigation into pipe construction failures showed that the main problems were loose casing joints (51% of failures) and the use of improper materials (21% of failures). To improve the supply network reliability and reduce water and energy losses, the company invested in improving pipe construction skills and used a leak detection system to locate faults. Because the leak detection system did not work well with the old pipes, faults were also located using a thermal graphic camera and by injecting gas into pipelines.

District Heating Network Upgrade, Jiamusi city, Heilongjiang province, China

DBDH, Direct Access to District Heating Technology "Dalkia Management of Jiamusi Urban Heating Network," http://dbdh.dk/images/uploads/pdf-news/hotcool_1_2010_low.pdf

Because of a chronic lack of funds, Jiamusi district heating network maintenance was minimal for many years, resulting in large energy and water losses. Interruption of service and low indoor temperatures were the norm, causing increasing dissatisfaction among users. To remedy the situation, in May 2007, the network operator, Jiamusi Heating Company (JHC), which is owned by the municipality, signed a 25-year agreement with an ESCO to manage the network. The ESCO undertook large-scale upgrades to improve performance. The heat supply temperature was raised, 90 new substations were built, and a

Supervisory Control and Data Acquisition (SCADA) system was installed. These upgrades enabled real-time management of the substations and network, improving energy efficiency and user comfort. Water losses were reduced by 30% and energy consumption by 13.5%. By improving service quality, the company improved its customer relationships and was able to reduce its debt rate from 7% to 2%. The network has begun expanding, and, after two years of operation, has increased its supply by 56% from 5.5 million square meters (29% of the total heating surface in Jiamusi) to 8.6 million square meters.

Attributes

- Carbon Savings Potential
Medium
Depends on the scale and technology used for district heating system upgrade
- First Cost to Government
Medium
\$0.10 - \$0.30/annualized kWht savings, maximum incentive for system upgrade
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced carbon emissions, improved air quality, enhanced public health and safety

Tools and Guidance

DHCAN. 2006. *District Heating System Rehabilitation and Modernization and Modernization Guide*. <http://projects.bre.co.uk/DHCAN/pdf/Modernisation.pdf> -- A guidance document for technical improvements to increase energy efficiency and reduce primary energy use, which offers a range of solutions from low-cost to high-cost, with consideration of financial circumstances, and links this to the need for a strategic view

IEA. 2004. *Coming in from the Cold- Improving District Heating Policy in Transition Economies*. <http://www.iea.org/textbase/nppdf/free/2004/cold.pdf> -- A summary of institutional experiences with district heating rehabilitation, focusing on developing clear district heating policy

ESMAP. 2009. *Public Procurement of Energy Efficiency Services*. http://www.esmap.org/Public_Procurement_of_Energy_Efficiency_Services.pdf -- A guide to good procurement practice from around the world

P04: Transformer Upgrade Program

Description

The networks that transmit electrical energy from generation plants and distribute it to end users utilize varying voltages to ensure efficiency and safety. Transformers either “step up” or “step down” the voltage of electricity as it is transmitted from one part of the network to another. When a transformer shifts electricity voltage, energy is lost. The age of and materials used in the transformer, along with other factors, affect overall transformer efficiency; as a result of advances in materials, modern transformers can be significantly more efficient than older models. Transformer audits can inform an appropriate upgrade strategy. This recommendation aims to identify opportunities to upgrade and replace transformers to improve efficiency.

Strategic replacement of existing transformers can improve distribution network energy efficiency and reduce transmission losses and carbon emissions and can also increase system resiliency, making electricity service more reliable.

Implementation Strategy and Challenges

Transmission and distribution infrastructure is often owned by utilities but regulated by local, state, or national bodies. Options for increasing transmission and distribution network efficiency include feasibility studies, direct expenditures and procurement, legal or statutory requirements for efficiency, and contracts with energy service companies (ESCOs).

Implementation Activity	Description
Feasibility study	The local, state, or national power authority (PA) engages a team that includes power and electrical engineers and financial advisors to ensure the feasibility study captures all pertinent information. The feasibility study establishes technological and financial viability of the upgrade program as well as procurement and policy options. The study also determines the baseline energy expenditure associated with power supply, technical distribution losses, and the efficiency of network transformers. Technical ability, procurement methodology, incentives, and taxes should also be considered. Each option should be evaluated in light of the PA’s specific requirements and capabilities. The feasibility study is the basis for selecting the transformer upgrade strategy.
Direct expenditures & procurement	The PA invests in a transformer upgrade. The main expenditure associated with a replacement program is the capital cost of the transformers. The PA pays these costs directly out of the city budget, and recoups the investment over time through lowered primary fuel costs. This approach is only appropriate when the PA owns the power utility.
Energy Services Company	As an alternative to direct expenditure, the PA contracts with an ESCO to finance and take ownership of the project. The benefit of this approach is that the PA does not have to commit to a significant financial investment or be responsible for project-related risks. There are a number of potential ESCO contractual structures; it is recommended that PAs explore the advantages and

	disadvantages of each.
Legal or Statutory Framework	The PA creates a legal or statutory framework that requires minimum efficiency levels for power distribution transformers. Efficiency levels should be set to ensure that the replacement program is staggered, targeting the worst-performing transformers first. The standard should apply to all transformers, not just those owned by electricity distribution companies because otherwise these companies could circumvent the framework by selling transformers to customers or third parties. Investment by electricity distribution companies is mainly controlled by regulation because distribution grids are typically natural monopolies. Therefore, the regulation scheme will have a large impact on the investment decisions of electricity distribution companies, including whether or not to buy energy-efficient distribution transformers. For national or regional policy affecting electricity distribution networks, the PA should lobby the higher levels of government for the necessary legal or statutory frameworks.

Monitoring Metrics

The power authority in charge of regulating the transmission and distribution infrastructure should perform the following activities to ensure a successful outcome and monitoring:

- Determine baseline input and output electrical power with a running load (kilowatt hours per year [kWh/yr])
- Set the goal for loss reduction from transformer upgrades (kWh/yr)
- Determine input and output electrical power with running load after upgrade (kWh/yr)
- Compare actual and targeted performance

Case Studies

Effitrafo Replacement of Transformers, Endesa, Spain

Leonardo Energy. 2009. "Energy efficient distribution transformers." http://www.leonardo-energy.org/webfm_send/2732

To increase electricity transmission efficiency, Endesa, the largest electric utility company in Spain, developed a formula that allowed the company to calculate the optimum efficiency class of distribution transformers. These calculations resulted in changes to the company's general transformer purchasing policy, stipulating the purchase of distribution transformers that were slightly more expensive but far more efficient than the current average European practice. Endesa also replaced operational transformers that met national standards with higher-efficiency transformers. These changes reduced energy losses by 50 to 80%, and the payback period for the new transformers was only 1-2 years. For each 400-kilovolt ampere (kVA) transformer on the grid, the replacement program resulted in annual energy savings of 5.5 megawatt hours (MWh) – the equivalent of 30 washing machines operating non-stop for one year. Other measures implemented by Endesa to increase transmission and distribution efficiency included installation of new transmission lines, replacement of existing conductors with large-diameter conductors, alterations in line voltage, and installation of capacitors in substations. For the

year 2008, the combination of these measures, including the replacement of distribution transformers, achieved energy savings of around 113 gigawatt hours (GWh).

Prison transformer upgrades, State of Arizona, USA

Ameresco. 2009. "Ameresco Begins Construction on Arizona State Agency's First Energy Service Performance Contract." <http://www.ameresco.com/release.asp?ID=191>

Outdated infrastructure and equipment as well as increases in energy costs and usage have significantly affected the Arizona State Prison Complex operating budget. The 850,000-square-foot complex consists of 190 buildings, including several high- and medium-security prisons, a central laundry facility, a food-processing area, and a medical clinic. An ESCO was contracted to provide energy conservation equipment, installation, maintenance, and services to reduce operational energy usage. The ESCO guaranteed approximately US\$7 million in energy and operational savings over the 13-year term of the performance contract. Replacement of low-efficiency transformers was a key component of the efficiency improvement program. Other measures included lighting system improvements, addition of lighting controls, implementation of energy management systems, water conservation, and a cooling tower replacement. Prison authorities estimated that the project would reduce average annual energy costs by at least US\$419,700 and reduce average annual operation and maintenance costs by US\$39,900, yielding a total annual savings of nearly US\$460,000. Any shortfall between the guarantee and the actual savings will be paid by the ESCO. Prison authorities will retain any savings in excess of the guarantee.

National Efficiency Standard, National Electrical Manufacturers Association, USA

Leonardo Energy. 2005. "The Potential for Global Energy Savings from High Efficiency Distribution Transformers." <http://www.leonardo-energy.org/repository/Library/Reports/Transformers-Global.pdf>

An efficiency standard applies to all transformers manufactured for sale in the U.S. or imported into the U.S. on or after January 1, 2010. The standard is a modification of the less stringent TP-1 standard, which had been developed by the National Electrical Manufacturers Association (NEMA), based on extensive studies by Oak Ridge National Laboratory in 1997 to determine whether energy conservation standards for distribution transformers would offer significant energy savings, be technically achievable, and be economically justified. The study estimated the cumulative energy savings potential from switching to high-efficiency transformers in the U.S. at 141 terawatt hours (TWh). One reason for this large figure is the large number of distribution transformers in U.S. utility networks. To reduce these losses, NEMA's TP1 standard defined a minimum efficiency for both dry- and oil-filled transformers in the range of 10 to 2,500 kVA. Transformers are also a part of the U.S. Department of Energy's ENERGY STAR broad voluntary energy labeling program. For transformers, ENERGY STAR encourages participating utilities to calculate the total cost of ownership of their transformers and to buy more efficient transformers types if it is cost effective to do so. ENERGY STAR for transformers is based on TP1 but may be tightened in the future.

Attributes

- Carbon Savings Potential
Medium
Savings depend on annual number of newly upgraded transformers and capacity of operating transformers in the program. Energy-efficient transformers lose 30% less energy (in Watts) than standard transformers, on average.
- First Cost to Government
Medium
\$0.10 - \$0.30/annualized kWh savings, maximum incentive for a KW capacity
- Speed of Implementation
<1 year
Upgrade or replacement might take 1 - 2 years, but a transformer can last more than 30 years. Payback time ranges from 5-7 years.
- Co-Benefits
Reduced carbon emissions, improved air quality, enhanced public health and safety, increased employment in transmission and distribution services and equipment sectors

Tools and Guidance

SEEDT. 2009. *Selecting Energy Efficient Distribution Transformers: A Guide for Achieving Least-Cost Solutions*. A guidance document for the technical-economic selection of distribution transformers
http://seedt.ntua.gr/index.php?option=com_remository&Itemid=15&func=fileinfo&id=107

SEEDT. 2010. "TLCalc." A tool for calculating and comparing energy, financial, and environmental parameters of distribution transformers
http://seedt.ntua.gr/index.php?option=com_wrapper&Itemid=36

SEEDT. 2008. "Policies and Measures Fostering Energy-Efficient Distribution Transformers." A guidance document for policies and measures fostering energy-efficient distribution transformers
http://seedt.ntua.gr/dnl/SEEDT_project_report.pdf

European Copper Institute. 2006. "Traloss Calculator." A tool for life-cycle cost calculations for transformers, which takes into account purchase price, life-time losses (load and no-load) and extra losses from harmonics. Typical harmonic profiles for the most important tools are embedded in the tool.
<http://www.leonardo-energy.org/life-cycle-costing-transformer-losses>

ESMAP. 2009. *Public Procurement of Energy Efficiency Services. Guide to good procurement practice from around the world*
http://www.esmap.org/Public_Procurement_of_Energy_Efficiency_Services.pdf

P05: Time-based Electricity Pricing Schemes: Inclining Block Pricing and Time-of- Use Pricing

Description

Time-based pricing refers to a type of contract offered by a service or commodity provider in which the price depends on the time at which the service or commodity is delivered. Block pricing and time-of-use pricing are two forms of time-based pricing used for electricity service in some countries.

Electricity prices are often determined by a complex rate-setting process unique to the jurisdiction and the regulatory structure of a given electricity market. In general, the price of electricity in a regulated market is based on the costs incurred to provide the service or, in a deregulated market, on competitive market prices (NAPEE 2009).

China's electricity price history illustrates the complexity of electricity price setting. Both wholesale generation prices and retail prices have undergone reform since the 1990s. Generation prices have evolved from being based loosely on average cost to include a coal price adjustment mechanism along with regional benchmark prices and facility-based prices for renewables, nuclear, and hydropower (Kahrl et al. 2011). Retail electricity prices have also increased gradually and are now, on average, comparable with the cost of supply but still fall short of covering each customer class's cost of service. In particular, social and affordability considerations have resulted in residential and agricultural electricity prices below the estimated cost of supply while the industrial and commercial sectors face higher costs (RAP 2008). Interruptible and time-of-use (TOU) pricing have also been introduced in China for industrial and commercial consumers and to a lesser extent for residential consumers.

For the residential sector, inclined block and TOU pricing could be introduced to promote energy savings and greenhouse gas emissions reductions.

Implementation Strategies and Challenges

Implementation Activity	Description
Inclining block pricing	Inclining block rates, also known as inverted block rates, are a fixed rate designed to encourage energy efficiency by charging more for incremental consumption beyond a minimum number of kilowatt hours (kWh). Inclining block rates include a basic customer charge (regardless of usage) and a fixed volumetric rate for the first usage block (e.g., the first 200 kWh consumed). For subsequent blocks of electricity consumed, the fixed volumetric rates increase, sending a price signal to customers to moderate additional usage. Inclining block rates can be applied to all consumer classes and provide high customer incentive for energy savings as well as medium customer incentive

	for peak demand savings (NAPEE 2009). However, their effectiveness depends on consumers' awareness of the pricing scheme and ability to recognize and act on the price signal. In the U.S., inclining block rates have been adopted in five states – California, Delaware, Maryland, Oregon, and Vermont – and the District of Columbia.
Time-of-use pricing (Critical peak/Real-time pricing)	TOU electricity pricing sends a price signal to consumers to reduce energy consumption during certain time periods and to shift loads to periods when usage is traditionally lower. In most cases, TOU pricing is set in advance for a specific time period, with lower off-peak prices and higher peak prices aimed at shifting power loads from peak to off-peak periods. In some cases, TOU pricing applies only on critical peak days, with prices intended to reflect the actual cost of generation or the wholesale electricity purchase price. If TOU pricing successfully shifts loads, it can help eliminate power shortages and increase the overall efficiency of the power sector by reducing or postponing the need for new capital investment and reducing the load factor of peaking coal-fired power plants (RAP 2008). A related form of time-based pricing is real-time pricing, which reflects the actual cost of electricity during specific hours of the day and year, using price signals to incentivize load shifting. However, real-time pricing's effectiveness is more difficult to assess because of major variations in pricing schemes and their secondary effect on energy efficiency.

Monitoring Metrics

The regulatory body in charge of setting electricity prices should perform the following activities to ensure a successful outcome and monitoring:

- Estimate reduction in energy demand after implementing inclining block rates
- Estimate reduction in electricity consumption during peak periods and the peak load rate after implementing TOU pricing

Case Studies

The Economics of Real-Time and Time-of-Use Pricing, USA

King, Chris S.. 2001. *The Economics of Real-Time and Time-of-Use Pricing For Residential Consumers*. <http://www.americanenergyinstitutes.org/research/The%20Economics%20of%20Time-Based%20Pricing%20for%20Residential%20Consumers.pdf>

“During the late 1980s, many utilities tested TOU rates, using large sample sizes and sophisticated measurement equipment and techniques. These utility studies show that TOU reduces peak consumption by about 20% on average, or 0.7 kW per residential customer, and total consumption by about 4.5%, or 450 kWh (EPRI & EEI). In 1989, using a typical value of US\$60/kW-year for avoided

capacity and US\$0.03 per kWh for avoided generation, the benefit of TOU rates to utilities was about US\$55 per customer-year. About 80% of this amount must be returned to TOU customers as the benefit of shifting their load, leaving about US\$11 per customer year for metering. This amount, US\$11 per year, is equivalent to a total capital cost of US\$69. By 2000, wholesale capacity and peak energy prices had doubled, increasing the savings to consumers to nearly US\$100 per year, with US\$22 available for metering, or an equivalent capital cost of US\$138. Savings from real-time prices are even higher. Applied to all residential customers in the U.S., a 10% reduction in peak would translate to about 20,000 megawatts (this is about the same as the peak load for all of Pacific Gas & Electric Company, the U.S.'s largest combined electric and gas utility). A 450-kWh reduction in consumption per customer translates to 40 billion kWh per year."

Attributes

- Carbon Savings Potential
Medium
TOU pricing is typically associated with peak energy demand reductions on the order of 3-6% for fixed TOU pricing and 13-20% for critical peak pricing (Faruqui and Sergici 2010). Short-term energy savings of 3.3% to 7.6% have also been reported (NAPEE 2009). Because peak generation is typically fossil-fuel based, incremental greenhouse gas emissions reductions are associated with reducing peak demand.
- First Cost to Government
Medium
Although the incremental greenhouse gas emission reduction from TOU pricing will depend on load shifting versus energy savings, which means that cost effectiveness of greenhouse emission reductions may vary, TOU pricing is cost effective in improving the efficiency of the power sector.
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced carbon emissions, improved air quality, enhanced public health and safety

Tools and Guidance

Pacific Gas and Electric (PG&E). 2013. What are time-of-use rates and how do they work? Time-of-Use Frequently Asked Questions.

<http://www.pge.com/mybusiness/energysavingsrebates/timevaryingpricing/timeofusepricing/>

San Diego Gas and Electric (SDG&E). 2013. Critical Peak Pricing Fact Sheet.

http://www.sdge.com/sites/default/files/documents/cpp_factsheet.pdf?nid=1381

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King, C. S. (2001). The economics of real-time and time-of-use pricing for residential consumers. American Energy Institute, Tech. Rep.

Faruqui, Ahmad, and Sanem Sergici. "Household Response to Dynamic Pricing of Electricity: a Survey of 15 Experiments." *Journal of Regulatory Economics* 38, no. 2 (October 1, 2010): 193–225. doi:10.1007/s11149-010-9127-y.

Kahrl, F., Williams J., Ding J., and J. Hu, 2011, "Challenges to China's transition to a low carbon electricity system." *Energy Policy* 39 (7): 4032-4041.

National Action Plan for Energy Efficiency, 2008. Vision for 2025: A Framework for Change, 2008. <http://www.epa.gov/cleanenergy/documents/suca/vision.pdf>

P06: Load Curtailment Incentives/Demand Response/Curtailable Rates

Description

Demand side management (DSM) refers to the funding and/or implementation of an array of tools that a utility or state entity uses to promote energy efficiency by modifying end-use electricity consumption. DSM programs aim to reduce overall consumption using energy efficiency measures or to reduce peak demand using load management and demand response. Similar to time-of-use (TOU) pricing, load management through demand response can reduce peak demand and thereby reduce the need for costly new construction. However, load management programs do not encompass all cost-effective demand-side potential.

DSM has been adopted by utilities in more than 30 countries, including the U.S., Australia, the European Union (EU), Thailand, and Vietnam. In China, DSM has recently been evaluated by different provinces and cities as an option for power sector management. DSM pilot programs and activities have been initiated in the cities of Shenzhen, Beijing, and Shanghai and the provinces of Jiangsu and Henan since the mid-1990s, with an emphasis on demand response programs using TOU and interruptible load pricing and end-use efficiency projects for large energy consumers. DSM has also been mentioned in national policies and documents.

In the U.S., for example, more than 500 utilities implemented DSM programs between 1985 to 1995, and total spending increased to \$1.1 billion in 2000 (NRDC 2003). Most of the utility programs in the U.S. are funded by a “public benefits” or “public goods” surcharge on customer utility bills that is a very small percent (<5%) of the total electricity and gas charges. A successful example of DSM has been in California where funding for utility DSM programs, including funds from a public benefits charge, increased substantially after 2001. A 2003 study found that California’s programs spent US\$893 million in 2001 to save 3,389 megawatts of summer peak demand and 4,760 gigawatt hours of annual energy use (Global Energy Partners 2003). China’s 2010 DSM regulation requires grid companies to invest in energy efficiency to reduce peak load and energy use by 0.3% annually.

Implementation Strategies and Challenges

Implementation Activity	Description
DSM Energy-Efficiency Programs	DSM energy-efficiency programs can be designed and implemented in various ways and may include any or all of the following measures (NRDC 2003): • Financial incentives to end users to modify energy use or switch to more energy-efficient equipment (e.g., efficient appliance rebates, recycling programs) • Entering into energy-efficiency performance contracts or other third-party arrangements • Educating end users about available efficiency opportunities (e.g., free or subsidized home audits, public energy-efficiency awareness campaigns) • Developing suppliers or end-use energy products and services (e.g., energy

	service companies [ESCOs])
DSM Demand-Response Programs	Demand-response programs focus on energy-saving strategies for periods of peak demand, typically in hot weather months and during the afternoon hours. Demand-response programs usually include price-based initiatives such as real-time pricing or critical peak pricing and incentive-based demand-response initiatives where participating customers are paid to reduce their loads at requested times (e.g., peak hours). For incentive-based demand-response programs, participation and curtailment may be voluntary or mandatory. Additionally, most mandatory curtailment demand-response programs feature direct load control, in which the utility can remotely control equipment at the participant's site to reduce demand. Demand-response programs have economic benefits for program participants and the electricity system because it increases capacity without new generation as well as improving reliability and performance (Albadi and El-Saadany 2007). Other incentive-based demand-response programs include (California Energy Commission 2007): • Load curtailment incentives in which customers are paid a set rate per megawatt-hour curtailed when requested on a day-of basis • Curtailable or interruptible rates in which customers pay a lower rate in return for agreeing to mandatory curtailment or interruption when needed • Direct utility load control of air conditioners and water heaters, for which customers receive a financial incentive • Other programs where customers bid and offer to curtail loads and serve as standby or replacement capacity for generation for utilities

Monitoring Metrics

The regulatory body in charge of setting electricity prices should monitor the following to ensure a successful outcome:

- Total resource economic efficiency
- Utility expenditures on program administration, including marketing expenses and incentive payments
- Change in monthly utility bills, adding incentive payments and subtracting participation fees and equipment costs incurred by the customer
- Impact on average rates
- Peak demand reduction
- Aggregate demand reduction

Case Studies

State of California Demand Response Program, USA

<http://www.cpuc.ca.gov/PUC/energy/Demand+Response/>

Demand response has been widely used by regulators and utilities to curtail peak demand when the cost to generate an extra unit of electricity is usually extremely high. Demand response reduces grid-wide operations costs as well as the environmental consequences of generating electricity (Eto 1996; Charles River Associates 2005; Albadi and El-Saadany 2008). California has adopted aggressive demand response programs to avoid constructing new power plants. To assess the cost effectiveness of the demand-response programs, the California Public Utility Commission (CPUC) developed the 2010 Demand Response Cost Effectiveness Protocols for utilities (CPUC 2010) with technical support from the firm Energy, Economics, and Environment (E3). This tool has been used to assess the costs and benefits of demand response programs by major California utilities, including, Pacific Gas and Electric, Southern California Edison, and San Diego Gas and Electric.

Attributes

- Carbon Savings Potential
Medium
DSM programs help reduce energy use, peak load, and greenhouse gas emissions to varying degrees, depending on the scale of the program and the electricity fuel mix. A 2003 study of California's 218 DSM programs found first-year energy savings of 4,760 gigawatt hours and 3,388 megawatts of demand savings. Since 1997, California's DSM programs have reduced air pollution emissions from stationary sources by an estimated 40% (NRDC 2003).
- First Cost to Government
Medium
The cost effectiveness of DSM programs can vary by program, but California's successful example has shown that DSM can be very cost effective with a lifetime cost of only 3 cents per kilowatt hour, or well below the lifetime cost of building new power generation (Global Energy Partners 2003). U.S. DSM programs have average up-front costs of 2 to 3 cents per kilowatt hour saved (NRDC 2003).
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced energy use, peak load, and carbon emissions; improved air quality; enhanced public health and safety

Tools and Guidance

SEEDT. 2009. *Selecting Energy Efficient Distribution Transformers: A Guide for Achieving Least-Cost Solutions*. A guidance document for technical-economic selection of distribution transformers http://seedt.ntua.gr/index.php?option=com_remository&Itemid=15&func=fileinfo&id=107

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Albadi, M.H., and E.F. El-Saadany. "A Summary of Demand Response in Electricity Markets." *Electric Power Systems Research* 78, no. 11 (November 2008): 1989–1996. doi:10.1016/j.epsr.2008.04.002.

Charles River Associates, 2005. *Impact Evaluation of the California Statewide Pricing Pilot*. Charles River Associates, Oakland, CA (2005)

California Public Utility Commission. "Attachment 1: 2010 Demand Response Cost Effectiveness Protocols." (2010): 07-01.

Eto, J. *The Past, Present, and Future of U.S. Utility Demand-side Management Programs*, December 1, 1996. <http://www.osti.gov/bridge/servlets/purl/491537-Ttec7Y/webviewable/>.

Global Energy Partners, 2003. "California Summary Study of 2001 Energy Efficiency Programs," Final Report to Southern California Edison and the California Measurement Advisory Council, Report ID#02-1099, Lafayette, CA: Global Energy Partners.

NRDC, 2003. *Demand-Side Management in China: Benefits, Barriers, and Policy Recommendations*. Site: <http://www.nrdc.org/air/energy/chinadocs/dsm.pdf>

P07: Power Investment Subsidies and Tax Incentives for Renewable Energy

Description

In investment subsidies, grants, and rebates, the government provides one-time compensation for a certain percentage of capital investment costs (REN21 2011). These subsidies are aimed at helping renewable power generators overcome entry barriers.

In terms of tax incentives, local and national governments use several types to encourage renewable energy development.

Investment tax incentive: Investment tax incentives are income tax deductions or credits for some fraction of capital investment in residential, commercial, or utility renewable energy projects (Clement et al. 2005).

Property tax reduction: Property tax incentives reduce or eliminate property tax for owners of land or real property used for renewable energy production (Clement et al. 2005).

Value added tax reduction: Value added tax programs exempt renewable energy producers from taxes on value added between the purchase of inputs and sale of outputs (Clement et al. 2005).

Excise (sales) tax reduction: Excise or sales tax programs exempt renewable energy equipment purchases from a percentage of excise or sales tax (Clement et al. 2005).

Import duty reduction: Import duty programs reduce or eliminate duties on imported equipment and materials used for renewable energy production facilities (Clement et al. 2005).

Implementation Strategies

Extensive international experience has documented several factors that contribute to successful incentive program design and implementation (Clement et al. 2005). First, the effectiveness of tax incentives in influencing renewable energy investment and consumption decisions depends on the size, scope, and time length of the tax incentive. Second, incentives and policies must be tailored to the developmental stage of the renewable energy industry and must change to reflect industry development. Third, interactions with other government policies and energy market conditions along with other supportive policy initiatives or measures should be considered when designing tax incentives.

Recently, there has been debate about whether tax incentives or direct subsidies are more cost effective in encouraging renewable energy projects. Particularly in the U.S., which has a production tax credit (PTC) for wind energy (and a popular cash grant that temporarily replaced the PTC), there is an interest in continuing to provide steady support for wind energy development at least cost to the federal government whose budget is under fiscal strain. Research by the Bipartisan Policy Center in 2011 showed that the cash grant could have provided the same incentive benefit to investors as the PTC for roughly half the total fiscal cost to the government, for projects deployed between 2004 and 2008

(Gorence, 2011). This is partly because renewable energy product developers often do not have large tax liabilities and have to rely on banks (which do have large tax liabilities) to finance the projects and receive the related benefits. Research by the Climate Policy Initiative in 2012 showed that “if the wind PTC was delivered as a taxable cash incentive, it would almost halve the cost to government while delivering the same benefit to wind projects” (Varadarajan, 2012). If tax-based incentives are used, the stakeholders’ tax liability and ability to use tax incentives should be considered during the policy design phase.

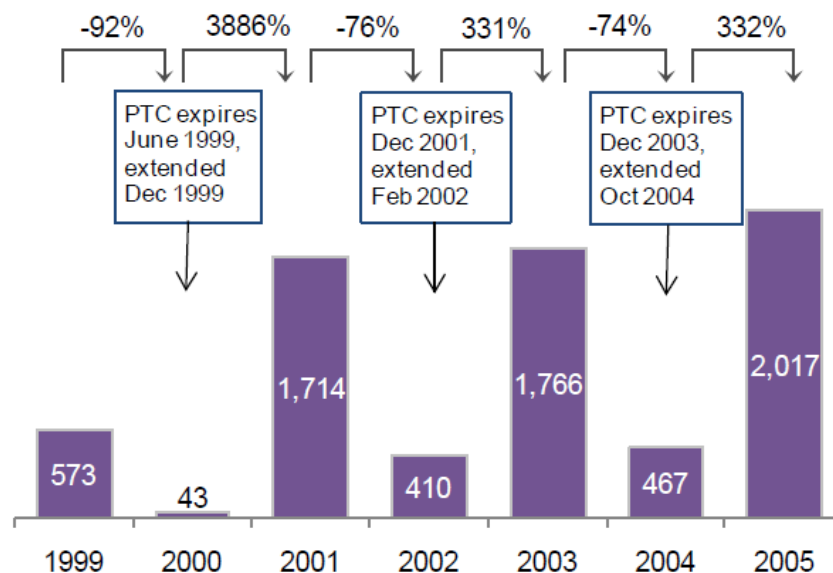
If direct subsidies or grants are provided up front, there is also a concern about a project’s later performance. For instance, a commercial building owner may receive an up-front grant for installing rooftop solar modules, install the project, but then later neglect to properly connect the panel to the grid or maintain the panel. Therefore, “pay for performance” incentives are often used, in which incentives are paid once energy-efficiency performance has been measured and verified. This discourages against poor project contracting or installation. For renewable energy, the U.S. PTC provides tax credits upon “production” or generation of each megawatt hour of power. At the very least, if a direct grant is used, strict project conditions should be outlined and met before the grant funds are paid.

Monitoring Metrics

At the national level, grants and tax incentive policies are typically administered by finance and tax-related government bodies. For instance, in the U.S., the cash grant program for wind and solar project development was managed by the U.S. Treasury. In China, the Golden Sun subsidy program for solar rooftop project development was managed by the Ministry of Finance. In the U.S., the Internal Revenue Service is involved in any tax-related policies. These bodies receive the applications for projects that are to be subsidized or to receive special tax privileges and are in charge of setting the investment conditions or performance metrics by which each project will be evaluated.

Case Studies

In the U.S., the wind PTC has been a very important incentive driving wind energy project development. Unfortunately, the PTC has been subject to unpredictable cancellations and extensions. A study by Bloomberg New Energy Finance, highlighted in Figure 2, showed that cancellation of the PTC resulted in an extreme drop in installations in the following year. Likewise, the extension of the PTC led to a boom in installations (Sharif, 2012). The availability of this incentive and its correlation with the number of installations clearly indicates that it is an effective tool driving renewable energy development.



Source: Bloomberg New Energy Finance, AWEA

Figure 2. US wind project installations, 1999-2005 (megawatts)

Attributes

- Carbon Savings Potential

High

Aside from the direct impact of incentives on increasing the utilization of renewable energy, it is difficult to quantify the greenhouse gas emissions reduction potential of these incentives. Program evaluation protocols have been developed by different organizations to attempt to evaluate or estimate the greenhouse gas emissions reduction or energy savings from a given policy or program (Vine et al., 2012).

- First Cost to Government

High

Fiscal incentives require government funding and are the most cost effective if supported by complementary policies and measures. The specific cost effectiveness varies by policy, depending on the size, scope, and length of the measure as well as the policy's design and usefulness to the stakeholder.

- Speed of Implementation

1-3 years

Tools and Guidance

Database of State Incentives for Renewables and Efficiency (DSIRE)

<http://www.dsireusa.org/>

http://en.openei.org/wiki/Gateway:Incentives_and_Policies

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Gorence, N., Mackler, S. 2011. *Reassessing Renewable Energy Subsidies*. Washington, DC: Bipartisan Policy Center.

Varadarajan, U., B. Pierpont, A. Hobbs, K. Rowley. 2012. *Supporting Renewables while Saving Taxpayers Money*. San Francisco CA: Climate Policy Initiative.

REN21. Renewables 2011 Global Status Report. Renewable Energy Policy Network for the 21st Century, 2011.

Sharif, D., A. Grace, M. Di Capua. 2012. *The return – and returns – of tax equity for US renewable projects*. New York NY: Bloomberg New Energy Finance.

Vine, E., N. Hall, K. Keating, M. Kushler, R. Prael. 2012. “Emerging issues in the evaluation of energy-efficiency programs: the US experience.” *Energy Efficiency* 5:5-17.

Street Lighting Policy Recommendations

- SL01: [Public Lighting Plan](#)
- SL02: [Audit and Retrofit Programs](#)

SL01: Public Lighting Plan

Description

A large fraction of roads and public spaces throughout the world have either insufficient or energy-inefficient lighting, leading to high energy expenditures and excess greenhouse gas emissions. For instance, the City of Melbourne spent AUD2,183,796 (13.3 million RMB)⁴⁵ on electricity in 2003-2004, of which lighting accounted for 61% of that expenditure (City of Melbourne, 2005). Another negative impact is that luminaires with indirect lighting cause light pollution in the public surroundings and night sky, which causes aesthetic pollution and may cause problems for astronomical observations. Non-shaded lamps also cause glaring, which has serious consequences for traffic safety, especially for the elderly. An integrated public lighting action plan will help identify appropriate technical and management measures to significantly increase the energy efficiency of public lighting while providing sufficient light for the specified use. Co-benefits include reduced electricity costs, greenhouse gas emissions, and light pollution.

Implementation Strategies and Challenges

Implementation Activity	Description
Public Lighting Assessment	An audit of the existing lighting stock and an assessment of operations and maintenance will help identify appropriate measures to significantly increase energy efficiency. Retrofits and new technology installations will both aim to increase the design life of luminaires and reduce maintenance costs. The aim of this activity is to enable a holistic assessment of the lighting system to identify areas for improvement across the network. See the related case study in Gaia, Portugal.
Retrofit Program	New lamp technologies can often significantly increase efficiency and product lifetime. Retrofits can deliver the same lighting levels with reduced energy consumption, carbon emissions, and operational costs. An increased design life reduces maintenance requirements and costs and also reduces interruptions to service, improving public health and safety. Details can be found in P02.
Procurement Guide for New Street Lights	Prepare a design manual for public street lighting which follows best practice Illuminating Engineering Society (IESNA) public lighting visibility and safety guidelines. The design manual should include parameters for illumination, pole spacing recommendations, luminaire and lamp type recommendations, and dimming or time of night illumination operations for all types of typical

⁴⁵ The average exchange rate of the Australian dollar and Chinese RMB yuan in 2004 was 1 AUD = 6.0988 RMB. <http://aud.fx-exchange.com/cny/exchange-rates-history.html>

	streets within a given city. Prepare an RFP for energy service companies (ESCOs) to bid on providing street lighting illumination for the city. The requirement should include design, installation, maintenance, and operational (energy) costs. The contracts should be for a long time period (more than 10 years) and include strict requirements for illumination (minimums and maximums). Require all procurement submissions for purchasing of new street lighting installations, lamp replacement purchases, or maintenance costs to provide a life cycle analysis of first cost, maintenance costs, and energy costs over the span of seven years. See case study in Midlands Highways Alliance, UK.
Lighting Timing Program	A program with strategic timing and/or dimming tailored to the specific needs for lighting in specific areas can significantly reduce energy consumption while still delivering appropriate levels of lighting for providing safety and sense of security in public areas. An intelligent monitoring system can be used to adapt the levels of lighting according to varying weather and activity levels. Often lighting timing programs are integral to a full audit and retrofit program, but for cities that already have energy efficient public lighting systems, a lighting timing program may still be a small and effective program. See case study in Oslo, Norway.

Possible challenges for implementing this measure include: lack of financial and human resources, and lack of data and information on current stock of public lighting and its energy efficiency.

Monitoring Metrics

The city authority in charge of implementing or contracting any public lighting system upgrade should monitor the following quantities to ensure a successful energy savings outcome:

- Percent of public lights inventoried for luminaire type and lamp type.
- Lumens / Watt - efficacy of illumination for currently used lamps and future lamp procurement.
- Watts / km – average energy used for street illumination for different street widths and types.
- Hours per year public lights are illuminated at maximum output and at less than 50% of maximum output (these quantities should be normalized for daylight if compared across cities).

Case Studies

Sustainable Public Lighting Action Plan, Melbourne, Australia

http://www.melbourne.vic.gov.au/AboutCouncil/PlansandPublications/strategies/Documents/sustainable_public_lighting_plan.PDF

The City of Melbourne developed a Sustainable Public Lighting Action Plan for the years 2005-2010. The aim of the plan was to minimize the environmental impacts of public lighting, while continuing to provide high quality lighting in the city. The Sustainable Public Lighting Action Plan identified four priority action areas: energy efficiency, renewable energy and offset options, waste management, and better management of public lighting. The public lighting target for 2007 was to achieve a 34% reduction in associated carbon emissions from public lighting from base year levels through planned energy efficiency and green energy purchasing initiatives. A longer term greenhouse reduction target for 2010 was to be set during this period to ensure a considered application of the most energy efficient technologies through a planned, cost effective approach. In order for effective implementation, a steering committee was created to provide leadership and ensure that cross-council awareness informs the sustainable public lighting agenda.

Energy efficient public lighting, Gaia, Portugal

<http://www.managenergy.net/download/nr20.pdf>

The Gaia Municipality in Portugal enacted a study with the main objective of reducing energy consumption in public lighting across the municipal area. The project was divided into four phases. The first phase evaluated existing public lighting conditions and available energy efficient technologies. The second phase developed a pilot project to confirm the theoretical results of flux control systems. In the third phase, a financial model for project implementation was developed. Finally, the project was implemented using a third party financing model, and a communication campaign was then enacted in order to disseminate information on the project to the public.

The preliminary study found that the best technical solution was the installation of flux control systems. These systems typically realize energy savings of 20-30% and increase the life span of lamps by up to 30%. The first stage of the project saw the installation of 30 flux control systems leading to an energy savings of USD 45,000 (372,600 RMB). The total investment was approximately USD 225,000 (1.86 million RMB), which will lead to payback period of five years, not taking into account the savings from reduced maintenance costs.

Midlands Highway Alliance (MHA), UK

<http://www.emcbe.com/Highways-general/idea%20case%20study.pdf>

Working under the East Midlands Improvement and Efficiency Partnership (EMIEP), the Midlands Highways Alliance (MHA) will save the region GBP 11 million (114 million RMB)⁴⁶ across highways maintenance and improvements by 2011 through efficiency measures for street lighting.

Supported by Constructing Excellence⁴⁷, the nine councils in the region and the Highways Agency have used a best practice procurement framework for major and medium-sized highways schemes and professional civil engineering services to achieve energy savings through energy efficiency measures. They shared best practices in maintenance contracts and jointly procured new efficient technologies in street lighting and signage. The case study linked here outlines the minimum and desired specifications for street lighting technologies in order to achieve the carbon emissions and cost reductions required.

Intelligent outdoor city lighting system, Oslo, Norway

<http://www.echelon.com/solutions/unique/appstories/oslo.pdf>

An intelligent outdoor lighting system has replaced PCB and mercury containing fixtures with high-performance high-pressure sodium lights. These are monitored and controlled via an advanced data communication system which operates over the existing 230V power lines using specialist power line technology. An operations center remotely monitors and logs the energy use of streetlights and their running time. It collects information from traffic and weather sensors, and uses an internal astronomical clock to calculate the availability of natural light from the sun and moon. This data is then used to automatically dim some or all of the streetlights. Controlling light levels in this way has not only saved significant amount of energy (estimated at 62%), but has also extended lamp life thereby reducing replacement costs. The Oslo city authority has been able to use the monitoring system to identify lamp failures, often fixing them before being notified by residents. With the ability to provide predictive failure analyses based on a comparison of actual running hours versus expected lamp life, the efficiency of repair crews has increased. Ten thousand replacements have cost the city authority approximately USD 12 million (75.7 million RMB). Currently, the program saves approximately USD 450,000 (2.84 million RMB) in running costs per year. However, it is estimated that if the program is rolled out to the entire city, the increased economies of scale will yield a payback period of less than five years.

⁴⁶ 2011 exchange rates published by HM Revenue & Customs of the UK government, 1 GBP = 10.37 RMB. See also: <http://www.hmrc.gov.uk/exrate/exchangerates-1112.pdf>

⁴⁷ Constructing Excellence is a UK-based construction industry membership organization. Its member organizations are drawn from across the industry supply chain, ranging from clients, through contractors and consultants, to suppliers and manufactures of building materials and components.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
<1 year
- Co-Benefits
Reduced carbon dioxide emissions; enhanced public health; financial savings

Tools and Guidance

Sustainable Public Lighting Toolbox. Available at: <http://www.iclei.org/index.php?id=6468>.

SL02: Audit and Retrofit Programs

Description

Public lighting systems typically use traditional incandescent lamps, which are highly inefficient providing little light and much waste heat in relation to their significant power consumption. They are also often poorly designed, in that they emit light, unnecessarily, in all directions equally, including the sky above, thus further increasing their energy inefficiency. New lamp technologies have significantly increased efficiency and lifetime. The aim of this recommendation is to explain how to assess current lighting efficiency through an audit and act to retrofit where appropriate.

Retrofits can deliver equivalent – or in cases, greater – lighting levels with reduced energy consumption levels, associated carbon emissions, and operational costs. An increased design life reduces maintenance requirements and costs and also reduces interruptions to service, improving public health and safety.

Implementation Strategies and Challenges

Implementation Activity	Description
Self-implementation	The main expenditures associated with a public/street/traffic lighting retrofits are lamp and fitting replacements, control system upgrades and replacements, and associated manual labor. These expenses along with consulting fees are funded directly by the city, which means the city accrues all financial benefits, but also bears the financial risks.
Energy Services Company Retrofit	An energy service company (ESCO) could also be contracted by the city to complete the project. There are multiple tactics for engaging an ESCO, including part- and full-ownership of the system therefore there are varying levels of benefit in terms of risk mitigation, upfront capital cost, and financial savings over the life of the project. If the ESCOs are based locally, this will help streamline the process and make the upgrade more feasible. Similarly, the presence of a local credible and independent contracting agency to conduct evaluation, monitoring, and verification (EM&V) minimizes contractual disputes by providing independent performance verification.
Supply and Install Contract	A supply and install contract gives the city flexibility to set performance parameters and review contractor performance as part of a phased project. This type of approach will require upfront spending, and establishing an appropriate financing plan is essential.
Long-term Concession	Long-term concessions free the city from financing pressures but will pass on financial savings accrued through energy saving to the body carrying out the upgrade. This strategy can be beneficial for cities without the financial resources to bear the upfront cost.
Joint Venture	A joint venture allows the city to maintain a significant degree of control over upgrade projects while sharing associated risks with a partner that is experienced in street lighting issues. Joint ventures are effective in situations where both parties stand to benefit from improved energy efficiency and do not have competing interests.

Possible challenges for implementing this measure include: lack of funding for both audits and retrofits, poor historical energy usage data availability, lack of technical capacity for conducting energy audits.

Monitoring Metrics

The city authority in charge of implementing or contracting any public lighting system upgrade should monitor the following quantities to ensure a successful energy savings outcome:

- RMB/km - Benchmark annual energy cost used for street illumination for different street widths and types.
- Lumens / Watt - average efficacy of illumination for the current operational city public/street/traffic lighting inventory, any proposed lighting inventory, and lighting inventory that is finally installed and operated.

Case Studies

Highway Sign Retrofit, San Diego, USA

http://www.greenerfacilities.org/admin/data/case_studies/Highway_Sign_lighting.pdf

In order to investigate the energy savings potential of a lighting retrofit, the California Department of Transportation replaced the lights used in overhead highway signs in San Diego County. The lighting used for overhead highway signs has specific requirements with regards to luminance, an absence of color shift over the lamp life, and a stable light output over a wide range of temperatures. The existing mercury vapor lamps were replaced with induction lights. These further took advantage of reflectors which optimized the distribution of the light, allowing lower-wattage lamps to provide brighter, more uniform light across the sign face. The retrofitting of lighting fixtures yielded energy savings of approximately 58%. In combination with the realization of substantial maintenance savings due to an increased design life, this retrofit saved USD 75-85 (473-536 RMB)⁴⁸ annually in energy costs per fixture. An added benefit was that they were much easier to install than their mercury vapor predecessors, as the lamps were significantly lighter.

Lighting Retrofit, City of Oslo

Clinton Climate Initiative, Climate Leadership Group, C40 Cities

http://www.c40cities.org/bestpractices/lighting/oslo_streetlight.jsp

The City of Oslo formed a joint-venture with Hafslund ASA, the largest electricity distribution company in Norway. Old fixtures containing PCB and mercury were replaced with high performance high pressure

⁴⁸ According to the World Bank's official exchange rate of 2012: 1 USD = 6.31 RMB.
<http://data.worldbank.org/indicator/PA.NUS.FCRF>

sodium lights and an advanced data communication system using power line transmission that reduces the need for maintenance. Intelligent communication systems can dim lights when climatic conditions and usage patterns permit. This reduces energy use and increases the life of the bulbs, reducing maintenance requirements. The system is now fully equipped with all of its components and is being calibrated to sort out some minor problems related to production failure in the communication units. Overall, the system has performed well under normal operating conditions.

Public square lights retrofit, Adelaide, Australia

<http://www.iclei.org/index.php?id=6665>

In April 2003, the City of Charles Sturt, Adelaide, replaced 17 of its 80W mercury vapor lamps on a public square with Light-Emitting Diodes (LED). As well as yielding environmental benefits from reducing the amount of mercury required to make each lamp and reducing light pollution caused by vertical light spill (i.e. light which is wasted by being projected into the sky above where it is not needed), these replacement LEDs yielded annual energy savings of approximately 85% due to their increased energy efficiency. The lamps are expected to last between 100,000 and 1,000,000 hours, meaning that they may not need to be changed for 20 years. Reductions in operational costs save the city authority USD 1,500 (9,465 RMB) annually in energy costs, with a payback period of just over 10 years.

Park and waterfront lights retrofit, Melbourne, Australia

http://www.portphillip.vic.gov.au/default/SustainableEnvironmentDocuments/Dio_Light_Case_Study.pdf

As part of its strategies to reduce energy consumption, the City of Port Phillip, Melbourne, chose to replace 290 lights along its waterfront walkways, parks, and piers. The existing 70W mercury vapor lights were replaced with more energy efficient light-emitting diodes (LED), which also have a longer design life, reducing overall needs for maintenance. During the retrofit program the city authority also noted that as the LED lights produced less heat than conventional lights, they were less attractive to insects, which reduced contamination of the lights by insects, thereby further reducing maintenance costs. By creating a 'moonlight' effect and avoiding the shadows produced by conventional public lighting, the new lights also enhanced public safety. Overall the replacement of 290 lights achieved an 80% reduction in energy consumption totaling 75,516 kWh. These energy savings combined with reduced maintenance needs resulted in financial savings to the city authority of USD 36,000 (227,160 RMB). As the total cost of the retrofit was approximately USD 100,000, the retrofit yielded a payback period of roughly 3.5 years.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
<1 year
- Co-Benefits
Reduced carbon emissions; enhanced public health and safety; increased employment opportunities; financial savings

Tools and Guidance

European Lamp Companies Federation. "Saving Energy through Lighting", A procurement guide for efficient lighting, including a chapter on street lighting. http://buybright.elcfed.org/uploads/fmanager/saving_energy_through_lighting_jc.pdf

Responsible Purchasing Network (2009). "Responsible Purchasing Guide LED Signs, Lights and Traffic Signals", A guidance document for maximizing the benefits of retrofitting exit signs, street lights and traffic signals with high efficiency LED bulbs. <http://www.seattle.gov/purchasing/pdf/RPNLEDguide.pdf>

ESMAP Public Procurement of Energy Efficiency Services - Guide of good procurement practice from around the world. http://www.esmap.org/Public_Procurement_of_Energy_Efficiency_Services.pdf

Solid Waste Policy Recommendations

- SW01: Integrated Solid Waste Management Planning
- SW02: Recycling and Composting Mandate and Program
- SW03: Landfill Methane Recovery
- SW04: Anaerobic Digestion
- SW05: Waste Composting Program
- SW06: Waste Vehicle Fleet Maintenance, Audit and Retrofit Program
- SW07: Public Education Program

SW01: Integrated Solid Waste Management Plan

Description

Integrated Solid Waste Management (ISWM) Plan is a comprehensive waste prevention, recycling, composting, and disposal plan. An effective ISWM system considers how to prevent, recycle, and manage solid waste in ways that most effectively protect human health and the environment. ISWM involves evaluating local needs and conditions, and then selecting and combining the most appropriate waste management activities for those conditions. The major ISWM activities are waste prevention, recycling and composting, and combustion and disposal in properly designed, constructed, and managed landfills.

- **Waste Prevention** – seeks to prevent waste from being generated. Waste prevention strategies include using less packaging, designing products to last longer, and reusing products and materials. Waste prevention helps reduce handling, treatment, and disposal costs, reduces production-related carbon dioxide emissions, and ultimately reduces the generation of methane.
- **Recycling and Composting** – a process that involves collecting, reprocessing, and/or recovering certain waste materials (e.g., glass, metal, plastics, paper) to make new materials or products. Some recycled organic materials are rich in nutrients and can be converted into compost for use as a soil additive to improve water retention, tillage, and nutrient levels.
- **Disposal (landfilling and combustion)** – used to manage waste that cannot be prevented or recycled. One way to dispose of waste is to place it in properly designed, constructed, and managed landfills, where it is safely contained. Another way to handle this waste is through combustion. Combustion is the controlled burning of waste, which helps reduce its volume and can produce useful energy. If the technology is available, properly designed, constructed, and managed landfills can be used to generate energy by recovering and burning methane. Similarly, combustion facilities produce steam and water as a byproduct that can be used to generate energy.

Implementation Strategies and Challenges

Implementation Activity	Description
Set achievable goals	When developing the integrated solid waste management (ISWM) plan, it is important to set achievable goals (e.g., protect human health, protect water supplies, eliminate open dumping, and increase recycling or composting).
Clarify responsibility	It is important to clarify responsibility of each level of government in the ISWM plan. For example, national governments typically set standards for solid waste management; the state, provincial or regional governments may help monitor and enforce these

	standards; and local governments often play the primary role of managing solid waste activities on a daily basis.
Provide adequate funding	All levels of government may provide funding for solid waste management activities. Two primary costs must be considered in any waste management system: initial capital costs (to purchase equipment or construct new facilities) and ongoing operations and maintenance costs. These costs can be funded in a number of ways including private equity, government loans, local taxes, or user fees.
Establish partnerships	It is critical to establish partnerships among producers, users, and government – all of which share responsibility for the environmental impacts of products in their life cycles – through engagement and education programs for better implementation.
Implementation, measurement and verification	In the implementing phase, measurement and verification can be applied to determine energy savings and the overall effectiveness of the plan.

Some possible challenges for implementing this measure include: lack of awareness of waste prevention and recycling opportunities; lack of financial and human resources for waste management activities; lack of local infrastructure for waste recycling and disposal; and lack of public awareness and relevant education programs.

Monitoring Metrics

The city authority in charge of implementing or contracting any ISWM plan could monitor the following quantities to ensure a successful waste management outcome:

- Recycling and composting rate
- Landfill and combustion rate
- Per capita solid waste production
- Reduced CO₂ emissions
- Recovered amounts of methane
- Investment costs of waste treatment facilities
- Energy (electricity and heat) generation from waste

Case Studies

Metropolitan Waste and Resource Recovery Strategic Plan, Melbourne, Australia

The Metropolitan Waste Management Group (MWMG), a statutory body of the state government in Victoria, Australia, produced the Metropolitan Waste and Resource Recovery Strategic Plan in 2009 (Victorian Government Department of Sustainability and Environment, 2009). The objective of the plan is to minimize the amount of waste that Melbourne generates and maximize opportunities for recovering materials. It has been developed to further deliver on key targets and intentions of Towards Zero Waste for metropolitan Melbourne. Its targets to 2014 cover all types of solid waste from all sectors. The strategic plan has been developed in three separate parts: the metropolitan plan (which assesses the current situation and sets the strategic framework for the management of all solid waste in metropolitan Melbourne), the municipal solid waste infrastructure schedule (which sets out a schedule of existing and required infrastructure for municipal solid waste) and the metropolitan landfill schedule (which sets a schedule identifying the location and sequence for the filling and operation of landfill sites). Substantial assistance has been provided to local government and industry through the landfill levy. The government has committed \$10 million (54.1 million RMB)⁴⁹ through the Victorian Advanced Resource Recovery Initiative to explore the provision of advanced resource recovery technology to process Melbourne's waste into clean energy and products, such as compost.

London Municipal Waste Strategy, London, UK

London's municipal waste strategy entitled "London's Wasted Resources" covers the full spectrum of waste treatment and recycling initiatives in the period from 2011 to 2031 (Great London Authority, 2011). Key targets for the management of municipal wastes include achieving zero municipal waste direct to landfill by 2025, and recycling or composting at least 50 per cent of municipal waste by 2020 and 60 per cent by 2031. According to the strategy, material not suitable for recycling would be dealt with using methods of generating energy from waste, such as combined heat and power (CHP), anaerobic digestion, gasification, and pyrolysis. The Greater London Authority (GLA) and London Waste and Recycling Board (LWARB) estimate 3.3 million tonnes of additional municipal waste management capacity is needed by 2031 requiring capital costs in the area of £800 - 900 million (7.79 – 8.77 billion RMB)⁵⁰ and annual operational costs of £60 -70 million (584 – 682 million RMB). LWARB's funds alone will not be sufficient, but it will leverage additional funding from other infrastructure funds and through private investment to help fill the capacity gap.

⁴⁹ The average exchange rate between the Australian dollar and the Chinese yuan in 2009 was 1 AUD = 5.4079 RMB. <http://aud.fx-exchange.com/cny/exchange-rates-history.html>

⁵⁰ Based on the average yearly exchange rate from 3/11/2012 to 30/04/2013: 1 British Pound = 9.7397 RMB. <http://www.exchangerates.org.uk/GBP-CNY-exchange-rate-history.html>

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
<1 year
- Co-Benefits
Reduced carbon dioxide and methane emissions, reduced waste and material use, increased employment, fuel savings

Tools and Guidance

United Nations Environment Programme (UNEP). Developing integrated solid waste management plan. 2009. Available at: <http://www.unep.or.jp/ietc/SPC/publications.asp>.

U.S. Environmental Protection Agency. Waste management resources. Available at: <http://www.epa.gov/tribalcompliance/wmanagement/wmwastedrill.html>.

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Victorian Government Department of Sustainability and Environment, 2009. Metropolitan waste and resource recovery strategic plan. Melbourne, March 2009. Available at: <http://www.sustainability.vic.gov.au/resources/documents/metropolitanwasteresourcerecoverystrategycplan.pdf>.

Great London Authority, 2011. London's wasted resource: the mayor's municipal waste management strategy. November 2011. Available at: http://www.london.gov.uk/sites/default/files/Municipal%20Waste_FINAL.pdf.

SW02: Recycling and Composting Mandate and Program

Description

Two important policy options for diverting valuable materials away from the waste stream to landfills are recycling and composting. Setting and implementing targets for diversion of waste from landfill drives local recycling and composting efforts.

Recycling involves recovering discarded materials such as plastics, glass, metals, and paper in order to sort, clean, and reprocess the used materials into new recycled products that can displace the need for new products made from virgin materials. Policies that promote recycling include setting recycling goals and requirements, recycling grants, tax incentives, beverage container deposit laws, disposal fee surcharges, and disposal bans. These policies have been adopted by a number of states and cities in the U.S. and countries in the European Union.

Composting involves recovering organic wastes (e.g., yard trimmings, food waste) and combining it with bulking agents to accelerate the breakdown of organic materials and transformation into fertilizers and mulch. Policies to promote composting focus on creating high market demand for compost, including favorable procurement policies in local governments and large institutions, landscaping and green building policies, and rebates and free giveaways for compost. In the U.S., the recovery rate of compostable yard trimmings and food residuals increased from only 12% in 1990 to 57.5%, with much lower compost rate of 2.8% for food waste due to high costs of food waste separation and collection (US EPA, 2012a).

Both recycling and composting can contribute to important energy savings and CO₂ emissions reductions, although the specific energy savings and emissions reduction potential may vary depending on the type of material being recycled and the composting method. The energy savings of recycling is determined by the type of material being recycled and the energy requirements for primary (virgin) production versus secondary (recycled) production of the material. In the example of aluminum, recycling aluminum can save 95% of the energy needed as compared to producing virgin aluminum. Overall, conservative estimates of energy savings of 22 Mtce in 2005 and reductions of 48 million metric tonnes of carbon emissions have been attributed to recycling programs in the U.S. (US EPA, 2012b). Diverting organic waste to composting can prevent the breakdown of organic waste in landfills, which generates methane emissions, a potent greenhouse gas. Composting under carefully controlled conditions for decomposition lower emissions from compost operations and has additional benefits in reduced pressure to expand forestry and mining production as well as fossil fuel extraction.

Implementation Strategies and Challenges

As with source reduction, the success of recycling and composting programs is contingent on general public awareness of the need and resources for recycling and composting that will lead to actual behavior change. This will often require education and outreach targeted at different consumer subgroups, as challenges may differ between single-house occupants and multi-family dwelling

occupants. The effectiveness of recycling and composting programs is also dependent on access to recycling and composting providers.

Some possible challenges to implement this measure might include: no infrastructure and proper channels for waste recycling and composting; low penetration of environment education; consumers' unawareness of the end-use for composting and thus no market demand for composting.

Monitoring Metrics

The city authority overseeing the implementation of any recycling and composting program can monitor the following quantities:

- Recycling and composting rate
- Per capita solid waste production
- Investment costs of recycling and composting facilities
- Maximum residuals per household

Case Studies

San Francisco Zero Waste Goals and Mandatory Recycling and Composting Ordinance

After meeting the state mandated goal of 50% landfill waste diversion in 2001, the city and county of San Francisco proceeded in March 2003 to set more stringent waste diversion goals at the local level by adopting goals of 75% diversion by 2010 and zero waste to landfill or incineration by 2020. In June 2009, the city also adopted mandatory recycling and composting ordinance which requires all city businesses and residents to separate their waste into recycling, composting, and landfill waste containers (San Francisco Department of Environment, 2009). The ordinance provides businesses, residential property owners, and renters with free recycling and compost containers, toolkits, educational materials, and trainings, while also making compliance enforceable through the use of fines if necessary. In addition to these two major recycling and composting policies, San Francisco has also adopted a variety of other complementary policies focused on producer responsibility for waste generation, plastic bag reduction, food service waste reduction, recycled content materials requirement for construction, debris recovery, and in-house recycling and procurement policies.

Zero Waste Strategy, Seattle, Washington, U.S.

City of Seattle's Zero Waste Strategy aims to achieve the goal of recycling 60 percent of waste produced in the city by 2012 and 70 percent by 2025. The city provides weekly food and yard waste collection to residential households. In early 2009, the mandatory food waste participation program (including curbside organics collection or backyard composting) went into effect for single-family households. This requirement expanded to all households up to four-plexes on September 15, 2012. Seattle's recycling and composting fees are some of the highest in the nation. Current organic collection rates vary from

\$4.65 (29.3 RMB)⁵¹ to \$8.95 (56.5 RMB) per month based on can/cart size (Seattle Government Office of Sustainability and Environment, 2012).

Europe's Best Recycling and Prevention Program, Flanders, Belgium

The Flemish government of Belgium mandates source separated collection throughout the region. In order to encourage improvements in separation, it also sets targets for per capita residential waste production, home composting, and maximum residuals, which must be met by all municipalities. As a way to discourage burying and burning, the government implemented landfill and incinerator restrictions in 1998 and 2000. As a result, landfilling of unsorted waste, separated waste suitable for recovery, combustible waste, and all pharmaceuticals were banned. Incineration of separated recyclables and unsorted waste was also prohibited.

In addition to incinerator and landfill restrictions, the Flanders Public Waste Agency uses financial mechanisms to discourage burying and burning. There is an environmental tax for residual waste treatment that ranges from €7 (66.7 RMB)⁵² per ton for incineration to €75 (714.6 RMB) per ton for landfilling. In 2009, the revenues from these levies totaled €28 million (266.8 million RMB). About 40% of this amount was used to finance the subsidies in the environmental agreements with the municipalities. Adding the taxes to the treatment tariffs charged per treatment, landfilling costs €135 (1286.2 RMB) per ton, while the cost of incineration comes to between €77 (733.6 RMB) and €137 (1305.3 RMB) per ton (Allen, 2012).

The Flanders Public Waste Agency also provides investment subsidies to municipalities and inter-municipal associations for waste prevention, separation, and treatment. In 2009, €5.5 million (52.4 million RMB) were provided as subsidies to build drop-off centers and compost plants, implement pay-as-you-throw systems, and conduct other activities.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced carbon dioxide and methane emissions, reduced waste and material use, fuel savings, job creation

⁵¹ World Bank official exchange rate of 2012: 1 USD = 6.31 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

⁵² European Central Bank official exchange rate of 2009: 1 EUR = 9.5276 RMB.
<http://www.ecb.int/stats/exchange/eurofxref/html/eurofxref-graph-cny.en.html>

Tools and Guidance

Bradley, A.L., 2010. "Compost quality best management practices." Northeast Recycling Council.
http://www.nerc.org/compost_marketing/compost_quality_best_management_practices.pdf.

U.S. Environmental Protection Agency. "Wastes." <http://www.epa.gov/epawaste/index.htm>.

U.S. Environmental Protection Agency. 2011. "Reducing greenhouse gas emissions through recycling and composting." May, 2011.
http://www.epa.gov/region10/pdf/climate/wccmmf/Reducing_GHG_s_through_Recycling_and_Composting.pdf.

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U.S. EPA. 2012a. "Composting: Basic Information."
<http://www.epa.gov/osw/conservation/rrr/composting/basic.htm>

U.S. EPA. 2012b. "Communicating the Benefits of Recycling."
<http://www.epa.gov/osw/conservation/tools/localgov/benefits/index.htm>

SW03: Landfill Methane Recovery

Description

Municipal solid waste management contributes 14% of global emissions of methane, the greenhouse gas second most responsible for climate change after CO₂ (IEA, 2009). Methane is released in the form of vented landfill gas (LFG), which is produced through bacterial decomposition of organic waste in landfills and open dumps. Instead of allowing LFG to be released into the atmosphere, it can be captured, converted, and used as an energy source. The main method for capture and recovering methane in LFG is to extract and collect it using wells and a vacuum system, where the gas can then be flared and used directly, to generate electricity, or to fuel combined heat and power systems.

In addition to expanding recycling and composting programs, regulatory targets for methane capture and recovery have been implemented in countries such as the U.S. and Canada to constrain methane emissions and slow the future growth of emissions. Other landfill methane recovery policies adopted in countries such as the U.S., U.K., Germany, Luxembourg, and South Korea include financial and tax incentives for methane recovery and use, inclusion of LFG in renewable portfolio standards or feed-in tariff programs, standardization of interconnection requirements to provide grid access for small LFG recovery projects, and technology development and demonstration policies.

LFG energy projects have direct energy reduction impacts by using recovered methane as an energy source to offset or replace traditional fuel sources such as natural gas in electricity generation and combined heat and power systems, or direct use in boilers, dryers, kilns, greenhouse, or other thermal applications. In addition, LFG energy recovery projects also reduce substantial methane emissions from landfills, as landfill methane emissions reductions of 60% to 90% are feasible depending on the LFG energy project design and effectiveness. A typical 3-MW electricity generation project using LFG can reduce 34,700 metric tons of carbon dioxide equivalent emissions, while a typical direct-use LFG energy project can reduce 32,300 metric tons of carbon dioxide equivalent per year (U.S. EPA, 2012a). In the U.S., the 520 existing LFG energy projects have helped reduce landfill methane emissions and avoided CO₂ emission by a combined total of 44 million metric tonnes of carbon equivalent.

Implementation Strategies and Challenges

Implementation Activity	Description
Assess landfill methane recovery potentials	It is necessary to assess landfill methane recovery potentials, possible siting options, and grid integration and landfill methane utilization conditions.
Assign financial resources	It might be necessary to provide financial resources such as feed-in tariffs, subsidies and tax credits for developers.
Provide technical assistance	The city authority could provide technical assistance, tools and methods for developers on project design,

	feasibility study, and environmental impact assessment, etc.
Clarify grid integration responsibility and procedure	The measure should clarify grid integration responsibility and procedure for local grids and project developers to ensure the investment returns for developers. In addition, penalties should be designed for those violating relevant regulations.
Monitor and evaluate	The city authority needs to monitor the development of landfill methane recovery projects. Ongoing evaluations on the cost-effectiveness and energy and carbon savings of these projects are needed to future policy adjustment and designs.

Some possible challenges for implementing this measure include: lack of awareness among the various stakeholders on the benefits of methane recovery and LFG energy project; lack of promotional education and awareness programs; lack of financial support for LFG project developers; lack of technical and institutional capacity for landfill gas recovery and utilization; lack of supporting policies and regulations such as interconnection requirements for purchasing energy from LFG projects and mandatory control of LFG emissions from landfills.

Monitoring Metrics

The city authority in charge of implementing a landfill gas energy program could monitor the following quantities to ensure a successful outcome:

- Annual volume of captured landfill methane
- Reduction GHG emissions
- Financial savings
- Total investment costs

Case Studies

South Korea's Ulsan LFG Direct Use Project

In 2002, a methane gas recovery system located at the site of a municipal landfill in Ulsan, South Korea, became operational as one of the earliest LFG energy projects in the country. The Ulsan project captured and transported LFG from the municipal landfill to an adjoining chemical factory where the LFG is burned as a fuel in boilers. The project's benefits include increasing financial savings in parallel with rising traditional fuel prices, with estimated savings of 38,931 RMB per day when compared to a similar facility running on natural gas (Larney et al., 2006). This LFG energy project has also resulted in annual

greenhouse gas emissions reductions of 101,475 metric tonnes of CO₂ equivalent. Besides illustrating the financial and environmental benefits of landfill methane recovery, the successes of the Ulsan plant also demonstrated the importance of strategic partnerships between government and project partners that facilitated the financing, capacity building, and training needed in establishing the project.

Landfill Methane Outreach Program, U.S.

The U.S. Environmental Protection Agency's Landfill Methane Outreach Program (LMOP) is a voluntary assistance program that helps to reduce methane emissions from landfills by encouraging the recovery and beneficial use of landfill gas (LFG) as an energy resource. By joining LMOP, companies, state agencies, organizations, landfills, and communities gain access to a vast network of industry experts and practitioners, as well as to various technical and marketing resources that can help with LFG energy project development. LMOP has a network of more than 1000 partners, publishes technical and outreach publications on its website www.epa.gov/lmop, provides initial feasibility studies for potential projects and training workshops and conferences (U.S. EAP, 2012b).

Attributes

- Carbon Saving Potential
Low
- First Cost to Government
Medium
The main costs of methane recovery through LFG energy projects include costs for project evaluation, purchase and installation of LFG recovery and energy generation equipment and operating and maintenance costs. At the same time, however, LFG energy projects have proven to be very cost-effective in generating significant revenue from power or fuel sales that offset the project's capital costs.
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced carbon dioxide and methane emissions, improved air quality, increased economic benefits through job creation and market development, conserved land

Tools and Guidance

U.S. Environmental Protection Agency, 2008. *"Clean Energy Strategies for Local Governments."* Landfill methane utilization.

http://www.epa.gov/statelocalclimate/documents/pdf/7.4_landfill_methane_utilization.pdf.

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<http://www2.ergweb.com/landfill/index.aspx>.

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SW04: Anaerobic digestion

Description

Anaerobic digestion (AD) is a process where microorganisms break down organic materials, such as food scraps, manure, and sewage sludge, in the absence of oxygen. By controlling the process, anaerobic digestion can produce two useful products: biogas and residual digestate (a nutrient-rich fertilizer). Biogas, made primarily of methane (60-70%) and carbon dioxide (30-40%), can be used as a source of energy similar to natural gas. The solid residual can be land applied or composted and used as a soil amendment. The benefits of anaerobic digestion include renewable energy generation (combined heat and power and transport fuels), greenhouse gas emissions reduction, and waste diversion.

In 2010, 162 anaerobic digesters generated 453 million kWh of energy in the United States in agricultural operations, enough to power 25,000 average-size homes. In Europe, anaerobic digesters are used to convert agricultural, industrial and municipal wastes into biogas that can be upgraded to 97 percent pure methane as a natural gas substitute or to generate electricity. Germany leads the European nations with 6,800 large-scale anaerobic digesters, followed by Austria with 551, UK with 213, and Sweden with 173 (Pew, 2011; UK parliamentary office of science & technology, 2011). In developing countries, small-scale anaerobic digesters are used to meet the heating and cooking needs of individual rural communities. China has an estimated 8 million anaerobic digesters (Pew, 2011).

AD technologies are well-proven and have been used to treat sewage sludge since the early 1900's. Nowadays, there is growing interest in processing food waste. Food waste accounts for 18% of municipal solid waste sent to landfills in the U.S., yet only about 2.5% of food waste is recycled nationwide (U.S. EPA, 2007). The U.S. Environmental Protection Agency awarded California's East Bay Municipal Utility District (EBMUD) with a grant to investigate the benefits and limitations of anaerobically digesting food waste from restaurants, grocery stores, and other food handling facilities. Sweden, Austria, Denmark, Germany and U.K. have led the way in developing advanced biogas technologies and setting up new projects for conversion of food waste into energy.

Implementation Strategies and Challenges

Implementation Activity	Description
Assess local anaerobic digestion potentials	It is necessary to assess local anaerobic digestion potentials, possible siting options, and grid integration and solid residual utilization conditions.
Design financial measures	It is necessary to provide financial measures such as feed-in tariffs, subsidies and tax credits for developers.
Allocate funding and human resources for technical assistance	The city authority should allocate funding and human resources to provide technical assistance, tools and methods for developers on project design, feasibility study, and environmental impact assessment, etc.
Clarify grid integration responsibility and procedure	The measure should clarify grid integration responsibility and procedure for local grids and project

	developers to ensure the investment returns for developers. In addition, penalties should be designed for those violating relevant regulations.
Implementation, measurement and verification	In the implementing phase, measurement and verification can be applied to determine energy savings and the overall effectiveness of the plan.

Financing is one of the most serious challenges for implementing this measure. Installation, siting, and the operation of digesters remain costly. The rate of return provided by feed-in tariffs may not be sufficiency to overcome the technological and feedstock supply risks that are greater than for other renewable technologies (UK parliamentary office of science & technology, 2011). In the U.S., the Energy Policy Act of 2005 required net metering to be offered to consumers upon request in every state, disparate policy implementation and electricity rates have hindered wide-scale adoption of anaerobic digesters for electricity from agricultural sources. California, for example, does not allow utility providers to apply standby charges, minimum monthly charges, or interconnection fees (DSIRE, 2011), but utility providers do not buy back excess electricity (Mullins and Tikalsky, 2011), leading many farmers to burn-off excess gas rather than to provide the utilities with free energy to the grid. Further hindering adoption are varying limits on the amount of electricity that may be sold back to the grid under net metering rules. Possible measures to address this issue include carbon tax, renewable portfolio standards, tax credits, low-interest loans, feed-in tariffs, and so on. Other barriers to the development of AD include a lack of guaranteed material supply and a lack of market acceptance on the use of digestate as a fertilizer. Technical service centers and other education programs would help deal with this barrier.

Monitoring Metrics

The city authority in charge of implementing or contracting any anaerobic digestion plan could monitor the following quantities to ensure a successful outcome:

- The total amount of biogas
- Annual electricity and heat production
- Annual fuel supply
- Infrastructure investment
- Reduced CO₂ emissions
- The impacts of digestate use on soil and water quality

Case Studies

The Wales Center of Excellence for Anaerobic Digestion, UK

<http://www.walesadcentre.org.uk/>

The Wales Centre of Excellence for Anaerobic Digestion has been providing support and technical services to the AD industry, industry stakeholders, policy developers, and regulators since 2008. Its aim is to facilitate the development of AD infrastructure within Wales, to foster innovative solutions that

maximize the environmental and economic benefits of the AD process and products, and to encourage long term growth of the industry. It also supports small to medium sized enterprises in the Convergence Areas of Wales to implement new or improved products, processes, or services associated with the AD and biogas industries. The Wales Centre of Excellence for Anaerobic Digestion is based in the Sustainable Environment Research Centre (SERC) at the University of Glamorgan in South Wales. The Centre is funded by the European Regional Development Fund (ERDF), the Welsh Government (WG), and the University of Glamorgan.

East Bay Municipal Utility District (EBMUD), California, U.S.

<http://www.epa.gov/region9/waste/features/foodtoenergy/>

In order to decrease food waste and mitigate climate change, the East Bay Municipal Utility District (EBMUD) in California is pioneering an innovative method of reducing the amount of food waste reaching landfills while simultaneously producing renewable energy. In Oakland, California, EBMUD's main wastewater treatment plant was the first sewage treatment facility in the nation to convert post-consumer food scraps to energy via AD. Waste haulers collect post-consumer food waste from local restaurants and markets and take it to EBMUD. In an anaerobic digester, bacteria break down the food waste and release methane as a byproduct. EBMUD then captures the methane and uses it as a renewable source of energy to power the treatment plant. After the digestion process, the leftover material can be composted and used as a natural fertilizer.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
1-3 years
- Co-Benefits
Renewable energy generation, greenhouse gas emissions reduction, waste diversion, increased employment

Tools and Guidance

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SW05: Waste composting program

Description

The organic portion of municipal waste (such as cuttings, vegetable food waste, and compostable packaging materials) can be converted into compost. Depending on its quality, the resulting product can be sold to farmers, used in the city's parks and gardens, distributed to residents, or used as a cover for landscaped verges and landfills. Composting can be an effective method of reducing the quantity of waste hauled to central waste processing facilities. Composting programs can also be part of recycling of waste where facilities and demand exists.

Direct benefits include reduction in the quantity of waste hauled to central waste processing facilities, reduced fuel use in waste treatment (due to removal of organic waste), reduced pressure on landfill, and reduced waste vehicle movements. Indirect benefits include increased employment opportunities, reduced waste vehicle traffic in residential areas, reduced carbon emissions, and opportunity to use existing resources to collect more segregated waste from larger or expanded areas.

Implementation Strategies and Challenges

Implementation Activity	Description
Household composting program	The city authority provides each household with composting bins to collect and compost organic waste. Citizen participation and public information are essential to the success of this implementation activity and clear information must be provided to households so that the waste is adequately sorted and composted. The resulting compost can be used in people's own gardens or neighborhood parks, or collected by trucks to sell to agricultural uses. This implementation activity requires that the majority of households have gardens in which to compost the waste (and use it) and is unlikely to work well in neighborhoods with smaller courtyard houses or flats. See New York and Scotland case studies for further details.
Neighborhood composting program	The city authority encourages neighborhood composting programs by providing shredders and land for composting the waste. Seek support from community organizations to deliver this program. Citizen participation and public information are essential to the success of this implementation activity and clear information must be provided to households so that the waste is adequately separated. The resulting compost can be used in neighborhood parks or collected by trucks to distribute for agricultural uses. The end use should be investigated early on in the program.

	This implementation activity can be launched initially as a pilot project in selected parts of the city to judge success. See the Dhaka case study for further details.
City wide composting program	The city authority collects organic waste from households or neighborhoods for composting. Aerobic methods of composting, such as windrowing, are generally cheaper and avoid methane emissions. Anaerobic methods, while more capital intensive, can be used as part of a waste-to-energy facility. Citizen participation and public information are essential to the success of this implementation activity and clear information must be provided to households so that the waste is adequately sorted. See Sydney and New York case studies for further details.
Investigate the implementation of integrated composting and recycling programs	The city authority conducts a feasibility study to investigate opportunities for implementing a recycling program within the city. A successful recycling program requires adequate infrastructure for collection and distribution, market demand for recycled materials, opportunities for buy-in (returning recyclables to source), and human resources, and the feasibility study should consider the entire life cycle of the recycled material for cost-benefit and energy savings. Work with operators and businesses to investigate the potential for recycling at commercial facilities, for example, food manufacturers collecting organic waste for composting or offices collecting paper for recycling. See Oslo and New York case studies for further details.
Incentives & taxes	The city authority provides incentives for composting waste, for example, by waiving collection charges on waste that is composted or recycled. This implementation activity might also be used to encourage citizens to return recyclables to source (e.g. land) where the demand for composts exists.

Some possible challenges for implementing this measure include: lack of awareness and knowledge on waste composting; lack of infrastructure (containers) and collection service; unawareness of potential market for composting products.

Monitoring Metrics

The city authority in charge of implementing or contracting out any composting plan could monitor the following quantities to ensure a successful outcome:

- Percentage of waste composted in city

- Percentage of organic waste treated by composting
- Reduction in fuel use due to reduced waste vehicle movements
- Percentage of waste composted in city

Case Studies

Waste Recycling Model, Sydney, Australia

http://www.c40cities.org/bestpractices/waste/sydney_recycling.jsp

This public/private partnership between Australian company Global Renewables and two Sydney Municipal governments is a highly successful waste recycling model – reducing carbon dioxide equivalent emissions by 210,000 tonnes annually and generating \$11.6 million (75.8 million RMB)⁵³ in revenue every year. Using a unique biological digestion and composting process the company is turning methane to energy without incineration, and creating 30,000 tonnes of certified organic fertilizer for farmlands across the state. This compost is improving the quality of soils for crop-growing, putting nutrients back into agricultural land used by the city.

Solid Waste Management Project, Dhaka, Bangladesh

"Solid Waste Management in Dhaka, Bangladesh: Innovation in Community Driven Composting"

<http://kitakyushu.iges.or.jp/docs/sp/swm/2%20Solid%20Waste%20Management%20in%20Dhaka.pdf>

"Solid Waste Management in Dhaka

City" <http://kitakyushu.iges.or.jp/docs/mtgs/seminars/theme/swm/presentation/3%20Dhaka%20%28P%20aper.pdf>

The Dhaka City Corporation (DCC), responsible for solid waste management in Dhaka, encouraged private and non-profit organizations to organize community waste management programs in line with the implementation strategies set out in the citywide Solid Waste Management Plan.

In 1995, "Waste Concern", a local NGO, initiated a small-scale, community-based project for composting organic municipal solid waste. Waste Concern's initiative had three aims: 1) capture value from the organic portion of Dhaka's solid waste, 2) create job opportunities for the urban poor, and 3) create business opportunities for local entrepreneurs.

After assessing the potential of composting in Dhaka and its related industry, Waste Concern estimated that 15% of Dhaka's municipal solid waste is collected by 87,000 people in the informal sector, who primarily recover recyclable waste and leave the organic waste for municipal collection. Based on their study, Waste Concern chose to implement a decentralized composting program, which would be labor

⁵³ In 2012, the average exchange rate between the Australian dollar and Chinese RMB was: 1 AUD = 6.5357 RMB. <http://aud.fx-exchange.com/cny/exchange-rates-history.html>

intensive and less costly compared to previous centralized programs (which had not succeeded).

In 1996, a pilot project was begun on a 1000 square meter piece of land donated by a local club. This was supplemented by a public awareness campaign for separation at source and payment of TK 15-60 (1.2-4.8 RMB)⁵⁴ per month for door-to-door collection, as well as investigating the demand for compost in Dhaka and its surrounding areas. By 2002, the programme produced 500 kg of compost per day by processing 2 tonnes of solid waste with the help of six workers. It was also aiming to reduce the composting time from 40 days by using inoculums (compost digesters) to accelerate the decomposition.

Waste Concern has developed a good network with the nurseries and fertilizer marketing companies to sell their compost at a price of TK 2.5 - 5.0 (0.2-0.4 RMB) per kg. The quality of compost is monitored in the laboratories of Soil Sciences Department of Dhaka University.

New York Composting Project, New York, USA

The New York City Department of Sanitation (2012) is responsible for collecting and disposing of waste generated by city residents and public institutions. An equal amount of commercial waste is handled by providing distributed sanitation infrastructure.

A 2001 study conducted by the Department revealed that 55% of the New York City waste stream is biodegradable. To accomplish the diversion of this significant quantity of organic material, the Department looked at two overarching strategies to recover the compostable fraction of the residential and institutional waste stream: centralized composting and decentralized (or on-site) composting. As part of these strategies, the Department oversees a wide variety of composting operations and educational projects including:

- A separate leaf composting site in each borough except Manhattan
- The nation's largest in-vessel, food-waste-composting facility at Riker's Island
- Citywide compost distribution to parks, ball fields, community gardens, and public greening projects
- Public education programs through the city's four Botanical gardens
- Pilot projects to assess the potential of different composting techniques to divert additional organic material from the waste stream.

Integrated Waste Management System, Oslo, Norway

Oslo has an integrated waste management system that is based on the Waste Management Hierarchy. In 2006, more than 200,000 tonnes of household waste were collected, and of this 1% was reused, 27%

⁵⁴ Based on the currency exchange rate of 5/9/2013: 1 Chinese Renminbi = 12.8 Bangladeshi Takas.

was recycled, 67% was burned to produce energy, and only 5% went to landfill. Carbon dioxide emissions were reduced by 58,000 tonnes through use of waste to generate energy for the city's district heating system (C40 Cities, 2012).

The households in Oslo finance the waste service by paying a mandatory fee. Each inhabitant pays \$100 (797 RMB)⁵⁵ per year on average. The operational cost is \$225 (1,793 RMB) per tonne of household waste collected. Management/staff costs are about \$5.5 million (44 million RMB). The total operational costs were \$55 million (438 million RMB) in 2006, with this sum met and exceeded by around \$750,000 (5.98 million RMB) given the income from household fees. Investments in new recycling stations are estimated to cost approximately \$75 million (485 million RMB)⁵⁶ in the period 2008-2011.

WRAP Project, Scotland, UK

WRAP is a not-for-profit company backed by government funding that works with businesses and individuals to reduce waste, develop sustainable products, and use resources in an efficient way. The Scottish Government (Executive) has supported WRAP's scheme on home composting. In the past three years, WRAP – in conjunction with local authorities, Scottish Waste Awareness Group (SWAG), and community sector groups – distributed over 100,000 home composting bins. WRAP also worked closely with SWAG to ensure that accurate information is provided to householders.

In 2006, WRAP distributed 54,000 bins in Scotland reducing the amount of waste put out for collection by an estimated 9,000 tonnes per year (Scottish Environment Protection Agency, 2007). In 2007-2008, WRAP intended to work with all local authorities in Scotland, to distribute a further 50,000 home composting bins, reducing the amount of waste put out for collection by an estimated 7,000-8,500 tonnes per year. WRAP estimates that the average diversion for each home composting bin distributed is approximately 160 kilograms per year. The Scottish Executive is considering if an allowance could be made in the Landfill Allowance Scheme to reflect the full impact of home composting.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
1-3 years
- Co-Benefits

⁵⁵ World Bank official exchange rate of 2006: 1 USD = 7.97 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

⁵⁶ World Bank official exchange rate of 2011: 1 USD = 6.46 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

Improved air quality, enhanced public health, increased employment opportunities, financial savings, reduced waste vehicle traffic

Tools and Guidance

WRAP home composting page: http://www.recyclenow.com/home_composting/.

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SW06: Waste Vehicle Fleet Maintenance, Audit, and Retrofit program

Description

An audited, maintained, and modern vehicle fleet can help ensure that waste collection and transfer is done in the most fuel-efficient manner possible. A “waste vehicle fleet maintenance, audit, and retrofit program” will typically involve measures that reduce fuel use per tonne of waste collected, such as through engine upgrades and improved fleet maintenance. The successful implementation of this recommendation will require an assessment of the current waste collection / transfer fleet to identify required upgrades. A well maintained fleet is directly linked to better waste vehicle performance and reduced fuel consumption. Co-benefits include improved road safety, increased reliability of waste services (reduced waste vehicle breakdowns), and reduced CO₂ emissions.

Implementation Strategies and Challenges

Implementation Activity	Description
Set fuel reduction targets	The city authority sets 5-year targets to improve fuel efficiency by a set percentage, for example reduce fuel use per tonne of waste by 20% in 5 years. A City Fleet Manager can be appointed by the city authority to oversee the measurement of fuel use, total waste collection quantity in a year, and kilometers travelled to set baseline KPI's (Key Performance Indicators) and targets for individual vehicles and the entire fleet. This implementation activity can be managed internally, which allows the city control and flexibility. However, this methodology is most effective when the city authority has a relatively high level of knowledge and experience and may not be appropriate for cities that do not have the resources to implement it. This implementation activity can also be used in conjunction with penalty fines for operators of inefficient vehicles or an inefficient fleet. Complementary Activity: Include vehicle fuel performance in procurement criteria See Tashkent and Oeiras case studies for more details.
Waste vehicle maintenance and renewal schedule	Where waste vehicles are owned by the city authority (or public waste management enterprise), appoint a Maintenance Manager who ensures that every vehicle is serviced as recommended by manufacturers. As part of this task, he/she seeks to replace all failing vehicles either by retrofit or replacement, taking into account long-term cost-effectiveness and increased productivity. Vehicles should be reviewed on a regular basis (at least

	once every year), with failing vehicles being ideally replaced by vehicles that can be serviced locally. Where waste services are outsourced, the city authority can require regular servicing and maintenance of vehicles to be a demonstrable condition of the contract. See Tashkent case study for more details.
Include vehicle fuel performance in procurement criteria	As well as standard vehicle procurement requirements, the city authority ensures that the newly developed KPIs (Key Performance Indicators) are recorded and set targets are met by potential suppliers. This should relate to both new vehicles procured by the city authority and procurement of waste collection services from third parties. See Gothenburg, Philadelphia, and Tashkent case studies for further details.
Penalties for not meeting targets	The city authority imposes penalty fines on operators who continue to run inefficient waste vehicles and who fail to demonstrate an improvement in fuel use in their fleet. Clear guidelines on fuel-efficient use of vehicles must be provided and time-bound action plans for improvement agreed with operators before penalty fines can be imposed. See California case study for further details.

Some possible challenges for implementing this measure include: lack of funding for waste vehicle maintenance, audit and retrofit; lack of technical assistance; lack of data and information on the current status of waste vehicle therefore it is difficult to make assessments to identify required upgrades.

Monitoring Metrics

In order to successfully implement a waste vehicle fleet maintenance, audit, and retrofit program, the city authority should measure and monitor the following quantities:

- Fuel use per vehicle per tonne of waste or km travelled
- Fuel use per tonne of waste treated in the city

The city authority can also establish the following oversight activities:

- Set a mandatory minimum efficiency rating for each waste vehicle and entire fleet, e.g., fuel consumption per tonne (or cubic meter) of waste collected per km travelled using case study information

- Measure waste collected either by weight or volume. It is possible to do this using vehicle counts (linked to vehicle volume), or weighbridge data.
- Create an accurate inventory of vehicles that is updated whenever a new vehicle is added or removed from the fleet (coordinate with city maintenance department)
- Regularly assess existing fleet against the minimal efficiency rating and previous years' efficiency ratings. Use vehicle performance information to assess additional measures required and program success.

Case Studies

Solid Waste Management Project, Tashkent, Uzbekistan

The post-Soviet transition severely disrupted Tashkent's Solid Waste Management (SWM), curtailing garbage collections until trash piled up in city streets causing risks to public health and safety. When the economy picked up again in 1997, the Uzbekistan city authorities sought advice and financial assistance from the World Bank and European Bank for Reconstruction and Development (ERBD) under the Tashkent Solid Waste Management Project. The project has led to the renovation of the waste collection vehicle fleet with modern equipment and waste compactors, improving their roadworthiness and operation ratio.

Service equipment for district garages and a central repair workshop was purchased through a public waste management enterprise (Spetstrans). This helped improve operation and maintenance of vehicles and equipment and reduced operation and maintenance costs (maintenance work was previously done by Hyundai and Daewoo Service centers at a higher cost) (World Bank, 2012). The upgrade of the waste fleet was carried out in conjunction with other improvements including the construction of three new district transfer stations, which increased operational efficiency of waste collection vehicles by reducing idle mileage. Equipment usage is audited under a regulatory framework that records the total waste collection quantity in a year, recording volumes of solid waste generation and removal. The \$56.3 million (355.25 million RMB)⁵⁷ project is being financed through loans of \$24 million (151.44 million RMB) from the World Bank, \$19.2 million (121.15 million RMB) from ERBD in addition to a grant of \$2.1 million (13.25 million RMB), and the Uzbek Government which has contributed \$11 million (69.41 million RMB).

Energy Study on Oeiras' Municipal Fleet, Oeiras, Portugal

The Municipality of Oeiras (CMO) worked in partnership with the Technical University of Lisbon (IST) on a project to carry out a review of the current performance of the municipal fleet, which included waste collection trucks. The objectives were to assess the fuel consumption by vehicle type, establish performance indicators (such as kilometers per liter), propose simple measures to improve efficiency (eco-driving training), study the potential of implementing alternative fuels (biodiesel and natural gas),

⁵⁷ World Bank official exchange rate of 2012: 1 USD = 6.31 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

and perform an environmental assessment. In the absence of complete data, the project used refueling data and mileage records to estimate the total fuel consumption of waste collection trucks and its impact on the municipality's budget. A more advanced fleet management system was planned for the later phases, utilizing technologies supported by GPS to allow for better control over fleet operations and improve the data available. The total project costs amounted to \$45,384 (286,373 RMB), fully supported by the municipality (European Commission, 2012).

By the end of 2006, OEINERGE (the project coordinator) estimated that simply by processing the existing used frying oils in the county into biodiesel and using it to fuel some of the fleet's waste trucks, a reduction of approximately 10% in fossil fuel consumption could be achieved. In addition to allowing the municipality to understand the full functionality of the waste vehicle fleet and helping identify the potential problems in its management, the project has had an important role for best practice dissemination, emphasizing the importance of data recording and monitoring to evaluate fuel and cost savings.

Solar-Powered Trash Compacter Project, Philadelphia, USA

The City Philadelphia has installed 500 "BigBelly" solar-powered trash compactors (manufactured in Massachusetts) and 210 recycling containers on its busiest commercial downtown streets for waste collection services. When the receptacle gets full, a signal is sent to a Streets Department monitoring station alerting it to the need for waste collection. The waste is compacted (using solar power) so containers can contain 150 to 200 gallons of waste (traditional public waste containers hold 10 to 12 gallons). This has reduced city waste collection vehicles trips from 19 per week to 5 per week, decreasing fuel usage and saving more than \$800,000 (5.05 million RMB) annually (Clinton Climate Initiative, 2012). City recycling rates have also increased thanks to the ease of depositing cans, bottles and newspapers in public spaces. The initial investment in the scheme amounted to \$2.2 million (13.88 million RMB), which was funded through a state recycling grant.

Renova Waste Vehicle Fleet, Gothenburg, Sweden

Renova, owned by 11 municipalities in the region, is responsible for around 80% of waste management activity in the city of Gothenburg. A third of Renova's waste management fleet is fuelled by natural gas. In 2008, the company launched the world's first hybrid refuse collection vehicle (RCV) in collaboration with Volvo and Norba and with financial support from the Energy Authority (Renova 2008 Press Release). The hybrid RCV is driven by electricity or diesel and always loads and compacts with electric power generated by the truck's natural gas fuelled engine. This means that the hydraulic systems can work even when the truck is shut down, reducing fuel-consumption from idling. In addition, the truck uses only electricity when moving short distances, when starting and accelerating up to 20 kilometers per hour and when stationary, loading, or compacting. Overall, the hybrid RCV achieves a total fuel

consumption reduction of at least 30% compared to a conventional RCV. The vehicle also reduces emissions of carbon dioxide, nitrous oxide, and particulate matter. The reduced noise of electric transmission improves drivers' working conditions and enhances road safety as the driver can more easily hear passing traffic.

The successful adoption of these vehicles was supported by enforced emissions zone legislation set by governments to provide a level playing field, coupled with incentives (financial support from the Swedish Energy Authority). As part of this project, Renova also carried out staff training such as "Heavy Eco-driving" courses from the Swedish National Association of Driving.

Solid Waste Collection Vehicles, California, USA

The Air Resources Board (ARB) of the California Environmental Protection Agency imposed regulations as part of a state-wide scheme to reduce fuel consumption and harmful emissions from heavy duty vehicles. The "Idling Reduction Program" is a regulation which applies to vehicles over 10,000 lbs (approximately 4.54 tonnes) gross vehicle weight (which includes waste trucks), limiting idling to five minutes within Californian borders. The program calls for new engine and in-use truck requirements as well as emission performance requirements for technologies which provide alternatives to idling the truck's main engine, for example, newer models of heavy-duty diesel engines will be fitted with a non-programmable engine shutdown system which automatically shuts down the engine after five minutes of idling. Penalty fines on operators running inefficient solid waste collection vehicles are imposed for non-compliance to the regulations set. The fines range from \$300-1000 (2031-6770 RMB)⁵⁸ per day to persuade operators to comply. Idle reduction alternatives can require out-of-pocket expenses for waste collection services, but the ARB estimates that cost recovery times are typically three years given the fuel and maintenance savings, dependent on the equipment selected.

The Idling Reduction Program is part of a wider group of regulations set to reduce emissions from heavy duty vehicles in the state of California, which provided \$112 million (758.24 million RMB) in financial assistance for diesel truck upgrades and truck grants to help local agencies and others comply with the regulations (Green Car Congress, 2010). The newly funded projects are also estimated to have brought 5,000 more efficient trucks to the roads.

Attributes

- Carbon Savings Potential
Low
- First Cost
Low
- Speed of Implementation

⁵⁸ World Bank official exchange rate of 2010: 1 USD = 6.77 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

<1 year

- Co-Benefits

Reduced carbon emissions, improved air quality, enhanced public health, increased employment opportunities, financial savings, operational efficiency

Tools and Guidance

SMS Temp Critical Guidance Paper. “Fuel Efficiency Factors and Calculations.” <http://www.smstempcritical.com/pdf/fuel-efficiency-gallon.pdf>.

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SW07: Public Education Program

Description

An informed and knowledgeable community is crucial to the success of a waste management program since it helps to ensure: 1) greater support of the program as the public gains a greater understanding of the reasons why it is necessary and important, and 2) improved program compliance as the public becomes aware of the personal responsibilities expected of them and others in the community, including the individual actions they can take to reduce waste production and increase the reuse and recycling of solid waste.

Implementation Strategies and Challenges

Implementation Steps	Description
Identify overall goals and audiences	The government needs to identify overall goals and audiences/targeted groups for this public education program.
Identify awareness program opportunities	Then it would identify activities that have the best potential for waste management and establish a baseline for waste management awareness.
Establish objectives of the waste management awareness program	The team can establish specified waste management objectives as a result of awareness program activities or less tangible objectives to change levels of awareness and alter the behavior of people.
Develop a communication plan	The next step is to develop a clear and useful communication plan, which includes existing lines of communication, target audiences, anticipated challenges, communication messages, and tools. Incentives and penalties need to be developed as well.
Implement the waste management awareness program	After planning and preparing the awareness program, the team would get the message out.
Evaluate the program	The team needs to evaluate the awareness program against original goals and objectives which will help determine if it is effective. Ongoing evaluations throughout the campaign provide the information needed to adapt the program and plan future activities to achieve the desired results.

Some possible challenges for implementing this measure include: lack of funding, lack of identifying targeted groups and goals at the initial stage, lack of incentive and penalty design, and lack of creative design of public education activities.

Monitoring Metrics

Once the city authority implements a public education program on waste management, they should measure the following quantities to track progress:

- Number of participants by specific programs
- Website visits and downloads of related information
- Total education program costs
- Percentage of citizens aware of and participating in recycling/composting

Case Studies

Sustained Investment in Outreach and Compliance Assistance, San Francisco, U.S.

http://www.spur.org/publications/library/article/toward_zero_waste

After meeting the state mandated goal of 50% landfill waste diversion in 2001, the city and county of San Francisco proceeded to set more stringent waste diversion goals at the local level by adopting goals of 75% diversion by 2010 and zero waste to landfill or incineration by 2020 in March of 2003. In 2009, the city enacted the Universal Recycling Ordinance, requiring all properties to separate trash, recyclable materials, and compostable waste in accordance with San Francisco's three-cart collection program. The San Francisco Department of the Environment, which is largely funded by refuse collection revenues, has a team of zero-waste specialists whose outreach efforts have significantly increased participation in waste diversion programs. The team provides technical assistance, audits and knocks on thousands of doors to provide information when the rules change. The Department of the Environment also annually distributes \$600,000 in grants to nonprofit organizations, to support innovation in reuse, recycling, composting, market development, and education that could cost-effectively further increase waste diversion.

Education and Outreach, Phoenix, U.S.

<http://phoenix.gov/publicworks/education/index.html>

The city of Phoenix provides a number of recycling education and outreach opportunities to its citizens. Some traditional education ways provided to citizens include taking a tour, making a presentation, putting up a booth at a weekend or evening special event, scheduling the education trailer, and visiting the school. The City of Phoenix also utilizes a number of nontraditional educational methods to spread the word on recycling, including their cooperation with the Valleywide Recycling Partnership and the Arizona Recycling Coalition. These two regional organizations disseminate information on proper solid waste management along with the many environmental education programs they provide. Additionally the City of Phoenix is working with the Phoenix Arts Commission's Percent for Art Project to use various artistic approaches to educating the public on the three R's (reduce, reuse, and recycle) of solid waste.

Attributes

- Carbon Savings Potential
Low
It is usually part of a waste management program and has indirect contributions to energy savings.
- First Cost to Government
Low
In Goodhue County of Minnesota (with the population of 46,183 in 2010), the total budget for solid waste management plan was \$703,000 (4.4 million RMB)⁵⁹ in 2012, while waste education accounted for \$6,000 (37,860 RMB).
- Speed of Implementation
<1 year
- Co-Benefits
Reduced carbon dioxide and methane emissions, reduced waste and material use, fuel savings

Tools and Guidance

U.S. Environmental Protection Agency. *"Tribal Solid Waste Outreach Materials."*

<http://www.epa.gov/region9/waste/tribal/outreach.html>.

UNEP, 2005. *"Solid Waste Management - Volume II: Regional Overviews and Information Sources."*

http://www.unep.org/ietc/Portals/136/SWM_Vol-II.pdf.

⁵⁹ World Bank official exchange rate of 2012: 1 USD = 6.31 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>

Transportation Policy Recommendations

- T01: Integrated Transportation Planning
- T02: Mixed-use Urban Form
- T03: Vehicle CO₂ Emission Standards
- T04: Vehicle Fuel Economy Standards
- T05: Commuting programs
- T06: Bike Share Programs
- T07: Improved Bicycle Path Network
- T08: Complete Streets
- T09: Public Transit Infrastructure: Light rail, BRT, and Buses
- T10: Congestion Charges, and Road Pricing
- T11: Parking Fees and Measures
- T12: Vehicle License Policies
- T13: Public Outreach on Transport Options
- T14: Clean Vehicle Program

T01: Integrated Transportation Planning

Description

Saving energy and carbon in the transportation sector requires *integrated transportation planning*: coordinated land-use policies and prioritized funding for low-carbon transportation modes and infrastructure.⁶⁰

Integrated transport planning for low carbon development has the goal of enhancing a community's accessibility to resources and services with: (1) low-VMT transport: transport options that reduce the Vehicle Miles Travelled per person and in total; and (2) low-carbon transport modes, from non-motorized transport to efficient, clean-powered vehicles.

Cities around the world, from Portland and New York to Buenos Aeries and Guangzhou, have utilized a hierarchy of transportation modes to lower carbon in their transportation sector (ITDP 2012). In order of importance, the low-carbon transportation modes are (Portland 2009):

- pedestrians
- bicycles
- public transit (rail and busses)
- freight and commercial vehicles
- high-occupancy passenger vehicles
- single-occupancy vehicles.

Non-motorized transportation is a central part of low carbon, integrated transport planning. Walking and bicycling can be promoted as an important element of urban transport development through planning, target setting, and infrastructure development. Policies that can help promote the shift towards non-motorized transport include improving access, convenience, and safety of cycling and pedestrian activity. At the same time, integrated transport planning also promotes utilization of existing infrastructure and services (i.e., coordination of infrastructure and development), while focusing on both access and mobility.

In addition to helping lower VMT and transport-related carbon emissions, integrated transport planning can also help establish an interconnected infrastructure for different transportation modes that improves the quality of community mobility. Other low-carbon transportation strategies—vehicle technology, fuel standards, incentives to influence traveler behavior—follow from integrated transportation planning urban form and infrastructure choices.

⁶⁰ In general terms, integrated transportation planning provides an overall framework for a holistic planning approach to resolving emerging transport issues at regional, sub-regional and local levels (Western Australian Planning Commission, 2012).

Implementation Strategies and Challenges

Priorities. To prioritize low-carbon transport modes, planning on transportation systems must be integrated with land-use development and budget allocations. Development of housing and commercial properties must prioritize walking and bicycling transport modes, and integrate walkability with access to public transit (bus and rail). This can be encouraged by local government and developers incorporating pathways and public transit connections, as well as safe crossing of roadways with motorized vehicles. Although several Chinese cities have been undertaking low-carbon transport pilot projects since 2009 under the guidance of the Ministry of Housing and Urban Rural Development (MOHURD), in many other cities, the priority must still shift away from roads for passenger vehicles (World Bank 2012; Zhou et al. 2011).

Funding. Experience from Helsinki, Sweden, to Queensland, Australia, shows that planning at the regional level—across districts of a city and/or neighboring towns—rather than planning by a single local agency, is helpful for mobilizing funding for low-carbon transport infrastructure (WAPC 2012; HSL 2013). Funding of low-carbon transport infrastructure can also be supported by utilizing revenue from other transport policies (parking fees, license fees, congestion fees). In addition, districts with ease of walkability and public transit access are shown to attract economic development.

Monitoring Metrics

- Some suggested measures that relate specifically to this recommendation are as follows:
- Vehicle kilometers travelled per capita
- Transport modal shares (% of trips by each mode)

Case Studies

Chicago Metropolitan Agency for Planning. Transportation Policy. Go To 2040. Chicago, USA

<http://www.cmap.illinois.gov/transportation-policy>

As part of Chicago's *Go To 2040* plan for "sustainable prosperity through mid-century and beyond," the Chicago Metropolitan Agency for Planning (CMAP) has developed an integrated transportation plan, in conjunction with Chicago's climate action plan and local government agencies. Key elements of the plan include: Congestion Mitigation and Air Quality; Bike and Pedestrian Task Force; Intelligent Transportation System; Transportation Network Monitoring with Congestion Performance Measures (regional indicators); Regional Freight System Planning; and Conformity Analysis for evaluation of air quality impacts from proposed transportation activities. The Transportation Improvement Program tracks local, state and federal expenditures. Chicago also uses evaluation criteria for Performance-based Funding, to be sure funding decisions are helping the metropolis meet its transportation goals.

Auckland's Integrated Transport Programme "One System" Plan, Auckland, New Zealand

<https://www.aucklandtransport.govt.nz/about-us/publications/PlansProgrammes/Pages/default.aspx>

The Auckland Plan sketches a 30-year spatial framework for the development of city livability, with the transportation system a crucial component. Integration of transport planning and investment with land use development is a priority, and is aimed at meeting targets for increased share of public transit, reduced greenhouse gas emissions, improved accessibility for city residents and visitors, and less congestion for public transport and freight. The city estimates nearly \$60 billion investment in transport infrastructure priorities over the next 30 years.

Attributes

- Carbon Savings Potential
Medium
- First Cost to Government
Low
- Speed of Implementation
3 years
- Co-Benefits
Energy savings, improved air quality, improved accessibility and convenience, enhanced public health & safety.

Tools and Guidance

Chicago Metropolitan Agency for Planning (CMAP). Transportation Policies and Go To 2040. Online: <http://www.cmap.illinois.gov/transportation-policy>

Queensland Government Department of Transport and Main Roads. "Integrated Transport Planning Framework." <http://www.tmr.qld.gov.au/Projects/Name/I/Integrated-Transport-Planning-Framework/Integrated-Transport-Planning-Framework-publications.aspx>

Western Australian Government. 2012. "Guidelines for preparation of integrated transport plans." http://www.planning.wa.gov.au/dop_pub_pdf/guidelines_integrated_transport_whole.pdf

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Institute for Transportation and Development Policy (ITDP), 2012. Sustainable Transport Awards: <http://www.itdp.org/get-involved/sustainable-transport-award/>

World Bank. 2012. Sustainable low-carbon city development in China. Axel Baeumler, Ede Ijjasz- Vasquez, and Shomik Mehndiratta, editors.

T02: Mixed-Use Urban Form

Description

An urban form that promotes mixed-use zoning in land-use planning can greatly reduce the need for motorized transport, thereby saving energy and carbon. Locating multiple urban needs in close proximity, such as food markets, restaurants, shops and service businesses, schools and parks, is sometimes referred to as a “20-minute neighborhood” (Portland 2009). Another example of mixed-use urban form and land-use planning in practice is the UK’s plan for urban development, which follows a “Proximity Principle” that advocates higher density, self-sustainability, and walkable communities (Buchan 2008). The ease of interaction with local businesses and residents can enhance the quality of life and economic viability of a city (CMAP 2012).

Land use patterns—urban form—greatly influence traffic patterns and volumes. When development is spread out (low density) and separated (isolated land uses), the number of trips made and the length of trips are higher than when development is more compact and different uses are intertwined. As a city grows, the physical scope of work, commercial, and residential spaces can increase the travel distance for urban residents. Spatial design in land-use planning can help reduce transport demand by emphasizing high density, mixed use communities to help foster shorter auto trips, greater biking and pedestrian activity and use of public transit. In addition, urban form and urban design can also help reduce vehicle traffic by enhancing the comfort, speed, cost, convenience, attractiveness and safety of walking, biking and transit services.

Implementation Strategies and Challenges

In China, national planning regulations already require local governments to consider the impact on transport when making planning decisions. For example, China’s 2007 Climate Change Plan set key goals that include supplementing existing planning policies with sustainable transport and reducing private vehicle use (NDRC 2007). This objective has also been evident in other planning policies, including regional development strategy guidelines and national port, network and airport development policies. This is also part of the implementation and policy reform process in the 2008 national planning framework, and must also be considered in climate change adaptation and mitigation guidelines. For new and emerging cities, more specific spatial planning design considerations and measures can be adopted to reduce the need for transportation.

Creating zones, neighborhoods, blocks, and districts with mixed commercial and residential use can help increase local destinations and eliminate the need for longer-distance travel. Clustering key daily destinations such as shops, schools, parks and public services help enable pedestrian activity for workers and residents alike by providing incentive and convenience to walking. Likewise, open space such as neighborhood and regional parks should be integrated into planning with walkable distances to promote walking (Calthorpe 2010). Complementary to these spatial designing principles are additional policies that can concurrently discourage the use of cars. This could include limiting the total number of

permitted parking spaces in new developments and charging fines for parking over the limit in existing developments.

Within mixed-used urban neighborhoods, for vehicles that do pass through, city traffic congestion can be reduced by creating a dense networks of streets and paths that facilitate passenger mobility rather than vehicle throughput. This may include varying block size and street design to provide multiple options for different types of traffic including non-motorized transport and dispersing high traffic volumes over narrow, parallel routes rather than wide boulevards (EF 2010). One option is to increase the use of one-way couplets, one-way roads with opposing traffic flows that are typically found in densely populated cities such as San Francisco, New York City, Toronto, Seattle and Denver. These roads enable more bike lanes, shorten crossing distance and thus signal times and overall travel times can be reduced with more direct access and shorter block lengths (Calthorpe Associates 2010).

Monitoring Metrics

Some suggested measures that relate specifically to this recommendation are as follows:

- Walking distance to urban needs
- Avoided vehicle trips
- Permits and guidelines for mixed-use zoning
- Transport modal shares

Case Studies

20-minute Neighborhoods – Portland, Oregon (US)

Even with only 11% of the city designated as 20-minute neighborhoods, Portland residents already drive 20% less than residents of similarly-sized cities. Not only does the mixed-use urban save energy and carbon, it saves money on transportation. Portland Mayor Samuel Adams estimates that Portland's residents are nearly \$800 million richer every year by driving less frequently (Mahler 2013). With more data and education, even more progress can be made. Federal agencies typically base funding on the amount of car travel, whereas the 20-minute neighborhood zoning emphasizes "the trips not taken", i.e., avoided car travel. The city still needs to secure funds for necessary infrastructure investment, like pathways to the local market and school, or retrofit of utilities to accommodate mixed-use commercial and residential facilities, or connecting a community center and nearby streets with bicycle lanes.

Supporting Mixed-Use Habitats and Economic Prosperity - Tokyo

<http://nextcity.org/informalcity/entry/when-tokyo-was-a-slum>

One of the world's largest, densest, and richest cities –Tokyo – is also an excellent model of mixed-use urban form. Historical evidence shows that fitting infrastructure to local needs and patterns of building contributed to a world-class economy. Flexibility of land uses, live-work arrangements, and family-

owned, home-based businesses created a strong local economy in Tokyo, even as Japan promoted industrial development and a global export economy. And this urban form is also low carbon.

High-density neighborhoods with low-rise residences and mixed-use habitats evolved in Tokyo – they weren't made by advance planning or design. But the city acknowledged their importance and provided supporting infrastructure (water, gas, sewage systems, electricity, paths and roads). Even communities that were often discriminated against were eventually provided high-quality public services and permitted to continue home businesses. Many of the small businesses that are under threat in India and China, or have sadly vanished in some European and US cities, are still surviving in Tokyo: repair shops, artisan workshops, laundries and public baths, printing and woodworking, noodle shops and restaurants, martial arts schools and tutoring centers, convenience stores and offices. As a result, Tokyo has a high level of urban infrastructure, a wide variety of housing stock, and thriving mixed-used use neighborhoods.

Attributes

- Carbon Savings Potential
Medium
Neighborhoods with mixed-use urban form can save 40% of vehicle miles travelled (VMT) and CO₂e compared to less-dense urban areas (6 tCO₂e/household compared to 10 tCO₂e/household) (Calthorpe 2010). Dramatic savings of 70% are possible by avoiding long-distance commutes from low-density, residential-only, sprawl developments. For existing urban neighborhoods that shift to mixed-use zoning and complete streets, cities may achieve 30% savings in VMT and CO₂e within 10 to 20 years (Portland Climate Action Plan 2009).
- First Cost to Government
Low
- Speed of Implementation
>3 years
- Co-Benefits
Reduced fuel and/or electricity savings, reduced transportation costs, improved air quality, improved public health and safety

Tools and Guidance

Chicago Metropolitan Agency for Planning (CMAP). 2008. Urban Design Strategy Report. Effects of Good Urban Design. Online: <http://www.cmap.illinois.gov/strategy-papers/urban-design/>

Los Angeles Department of City Planning. 2011. CITYWIDE DESIGN GUIDELINES. Pedestrian-Oriented/Commercial & Mixed-Use Projects. Online: http://cityplanning.lacity.org/PolicyInitiatives/UrbanDesign/CommercialDesignGuidelinesHighRes6_23_2011.pdf

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T03: Vehicle CO₂ Emission Standards

Description

Vehicle emissions standards for carbon dioxide (CO₂), also known as GHG performance standards, aim to reduce transport sector emissions at the tailpipe. GHG emission standards for vehicles are similar to fuel economy or vehicle efficiency standards. The key difference is that the standard specifies the tailpipe GHG emissions resulting from the combustion of fuel, rather than fuel consumed, per distance traveled. In most cases, the standard is defined in terms of mass of CO₂ equivalent per distance, such as grams CO₂ equivalent per kilometer or mile traveled for new vehicles. Reduced GHG emissions from vehicles can also be obtained through a low-carbon fuel standard (policy aimed at the fuel, as a complement to policies aimed at the vehicle.) In addition, a GHG performance standard helps incentivize reduction of all GHGs from motor vehicles, including non-CO₂ GHG such as methane and nitrous oxide (Gallagher et al. 2007). At the same time, these standards also help create positive incentives to reduce oil consumption and increase fuel efficiency, as lower emissions result from less fuel consumed.

In the UK, manufacturers must test and rate their vehicles' CO₂ emissions. The CO₂ rating is connected to the fuel economy test; the vehicle is put through a mix of driving conditions in a lab. Purchasers pay a vehicle CO₂ fee based on the rating. There isn't required testing of vehicles' actual CO₂ emissions in operation. Some studies have found the actual CO₂ emissions can be 50% higher than the rating (European Commission, 2012). Unlike a "smog test" in which a vehicle's tailpipe air pollutant emissions can be measured directly, vehicle CO₂ emissions are generally based on engine tests of fuel combustion and fuel economy (The Green Car, 2012).

In the US, California targets for new vehicles, on average, will achieve CO₂e emissions reduction of 30 percent from the baseline year to 2016 (CARB, 2002). At the national level in the US, EPA uses a calculation, based on fuel economy of classes of vehicles, to estimate vehicle GHG emissions (EPA, 2012). In addition, the US EPA and the National Highway Traffic Safety Administration (NHTSA) are working on policies to encourage the production of clean vehicles, with reduced greenhouse gas (GHG) emissions and improved fuel use in a range of vehicle classes, from small cars to large trucks.

Implementation Strategies and Challenges

Implementation Activity	Description
Phase in Low-Carbon Vehicles in City Fleets	While most cities do not have the authority to set vehicle CO ₂ e emission standards, cities can promote low-carbon vehicles in their vehicle fleets, through purchasing and licensing requirements, rebates or tax incentives, or other measures.
Phase in Low-Carbon Fuels	Utilizing low-carbon fuels is another component of reduced tailpipe emissions of GHG. Cities can support infrastructure and encourage sales of low-carbon fuels within city boundaries, for city vehicle fleets.

Monitoring/Oversight

Some suggested measures that relate specifically to this recommendation are as follows:

- Grams CO₂ equivalent (CO₂, CH₄, and other GHG) per kilometer or mile traveled
- Testing of fuel economy with different fuels, for classes of vehicles

Case Studies

California vehicle GHG emission standards

In 2002, California enacted AB 1493 (“Pavley Global Warming Bill”), a law that requires reductions in greenhouse gas emissions from light-duty vehicles. The California Air Resources Board (CARB) is responsible for setting the standards, which apply to new vehicles starting in the 2009 model year. CARB received a waiver from the U.S. Environmental Protection Agency (EPA) to proceed with state-level rule-making. The standard requires that new vehicles, on average, achieve GHG emission reductions of 30 percent by 2016 and covers carbon dioxide, methane, nitrous oxide, and hydrofluorocarbon emissions. Under the Federal Clean Air Act, California is the only state with the ability to set standards for motor vehicles, as long as these standards are as stringent as the federal standards and the state receives a waiver from the EPA. More than fifteen states have adopted or have announced their intention to adopt the California standards. To complement the vehicle GHG emission standard, CARB is developing a suite of policies to promote cleaner vehicles, known as Advanced Clean Cars.

EU 2020 CO₂ emission standards for cars and vans

On July 11, 2012, the European Commission put forward two regulatory proposals that would implement mandatory 2020 CO₂ emission targets for new passenger vehicles and light-weight commercial vehicles (vans). The proposals now need only be confirmed by the European Parliament and European Council to become law. The existing CO₂ regulation for passenger vehicles has already led to impressive results: the average CO₂ emission level of new vehicles dropped from about 160 g/km in 2006 to 136 g/km in 2011 as measured on the European driving cycle, a 15% reduction. The annual rate of reduction is about twice what it was before introduction of mandatory emission targets.

Attributes

- Carbon Savings Potential
High
- First Cost to Government
Medium

- Speed of Implementation
1-3 years
- Co-Benefits
Reduced carbon dioxide emissions, improved air quality, improved public health, and fuel savings

Tools and Guidance

California Air Resources Board (CARB). Clean Car Standards - Pavley, Assembly Bill 1493. Online:
<http://www.arb.ca.gov/cc/ccms/ccms.htm> .

European Commission (2012). "Questions and answers on the regulation to reduce CO₂ emissions from cars." and "Questions and answers on the proposed Regulation defining the modalities for reaching the 2020 target for CO₂ emissions from new cars." Online:
http://ec.europa.eu/clima/policies/transport/vehicles/cars/faq_en.htm

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<http://www.epa.gov/otaq/climate/regulations.htm>

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US EPA, Green Vehicle Guide – About the Ratings. Online:
<http://www.epa.gov/greenvehicles/Aboutratings.do>

The Green Car. <http://www.thegreencarwebsite.co.uk/blog/index.php/how-are-co2-emissions-measured/>

The International Council on Clean Transportation. <http://www.theicct.org/eu-2020-co2-emission-standards-cars-and-vans>

T04: Vehicle Fuel Economy Standards

Description

A fuel economy standard is a tool that can be used to promote the production of fuel-efficient vehicles by manufacturers. This policy is usually set through regulatory or political means and mandates the average fuel consumption per unit of distance traveled, such as miles per gallon in the U.S. or kilometers per liter in Europe and Asia. Fuel economy standards can be implemented using different measures, including corporate (sales-weighted) average (U.S. former standards), fleet average (EU), weight-based (China), size-based (Korea) or vehicle footprint-based standard (U.S. revised) (An et al. 2011). Fuel economy standards help to induce technology innovation and drive improvements in vehicle fuel efficiency.

Fuel economy standards can play an important role in reducing GHG emissions. Fuel taxes may be set too low to promote sustainable transport choices, Because consumers do not consider fuel costs in vehicle purchase decision-making, a mandatory standard can help address this market failure. The standards inherently reduce CO₂ emissions by improving fuel efficiency and reducing the fuel burned, but there are no direct incentives for reducing the GHG content of the fuel (Gallagher et al. 2007). Compared to other policies promoting fuel-efficient vehicles, fuel economy standards are also more politically attractive and create certainty about the minimum fuel efficiency of new motor vehicles. However, fuel economy standards also have weaknesses in that they do not address the scale effect or the age effect of continued operation of older inefficient vehicles and do not induce innovation beyond the standard. In the absence of price signals, fuel economy standard may not affect driving behavior but may actually increase travel activity (i.e., the rebound effect may be observed).

Fuel economy standards are typically set at a national or centralized level because it has the authority to set requirements that must be met by manufacturer. On a local, city level, similar standards that mandate the average fuel consumption per distance traveled can be adopted for fleets controlled by city government, including taxis, buses or local government vehicle fleets. In doing so, the average fuel efficiency of the local vehicle fleets can be directly increased.

Implementation Strategies and Challenges

Implementation Activity	Description
Legislation	The City Authority mandates all passenger vehicles of a particular fleet (buses, taxis, local government) to be of a defined standard, or legislates in favor of efficient performance vehicles. Standards, compliance schedules and application require detailed consideration and consultation to ensure practical and achievable outcomes. Compliance with such programs can be enforced by traffic officers with fines and/or repossession of vehicles. Considerations of the percentage of the investment that can be borne by public authority, and the expected contributions of private owners are important for successful implementation. See Cairo case study for further details.
Licensing	The City Authority makes taxi-operating licenses contingent upon use of

	efficient vehicles or a minimum average fuel efficiency level, in accordance with the defined standard.
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Monitoring Metrics

- Some suggested measures that relate specifically to this recommendation are as follows:
- Fleet-average level of fuel efficiency

Case Studies

Mexico City – Taxi Fuel Economy

In Mexico City, the municipal government set a requirement to replace taxis that are at least 8 years old with more efficient models. New taxis must have a fuel efficiency of at least 12.5 kilometers per liter (29.4 miles/gallon). The local government provides a subsidy of nearly RMB 9,425 to drivers to buy a new taxi. To enable financing of the auto purchases, the municipal government formed a partnership with a local bank. The bank agrees to grant taxi drivers loans to pay off the typical remaining cost (approx. RMB 33,660), with a development bank acting as the guarantor of this loan. The government revokes the new car if the loan is not repaid by the driver (approx. 4 years). The first round of the program had a capital cost of RMB 28.3 million (C40 Climate Initiative 2010).

New York City, US – Efficient and Hybrid Taxis.

Cities in the US are also focusing on the fuel economy of taxi fleets. Because taxis are high-mileage vehicles, better fuel efficiency for taxis can achieve significant and immediate savings in energy and carbon. For example, taxis in New York City travel 80,000 miles per year, while a typical passenger car travels roughly 15,000 miles per year. Utilizing fuel efficient taxis could reduce GHG by 296,000 tons, the equivalent of taking 35,000 cars off the road. At 2011 gas prices, drivers of efficient and/or hybrid taxis could save an average of RMB 35,343 in gas costs per year. These efforts also improve air quality and human health; improved taxi efficiency can reduce lung-damaging nitrogen oxide emissions by 71 percent and hydrocarbons by 89 percent (New York City, Office of the Mayor, 2011). The newer, efficient taxis are being phased in, as replacements for retiring taxis. This approach also saves on life-cycle energy and carbon in the fleet. Other US cities are taking a similar approach. As part of the Minneapolis city climate action plan, the city requires that taxi vehicles licensed in the city achieve 23 miles per gallon (9.8 km/L) or better in local driving.

Attributes

- Carbon Savings Potential
High
- First Cost to Government
Medium

Over time, city government and taxi owners will realize cost savings due to fuel savings from more efficient vehicles. Initially however, city government will incur costs as it retires old, inefficient vehicles from its public fleets and purchases more efficient vehicles.

- Speed of Implementation
1-3 years
- Co-Benefits
Reduced fuel and/or electricity savings, improved air quality, improved public health

Tools and Guidance

Global Fuel Economy Initiative: <http://www.unep.org/transport/gfei/autotool/>

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T05: Commuting Programs

Description

Commuting assistance and commuting trip reduction programs are programs that provide residents with assistance to commute to work or school through car sharing and public transport. Specifically, these programs encourage employees or students to reduce driving and solo commuting and instead, provide incentives to residents to use alternative commuting options including public transit, carpooling, or biking. Examples of commuting assistance programs include carpool or vanpool incentive or subsidies, transit subsidies, reduced or free bike parking, free shuttles to major public transportation hubs, and pre-tax commuter benefit programs. By reducing solo commute trips as well as personal car use, commuting programs can help shift transport demand to non-motorized modes and incentivize greater utilization of more efficient, lower emissions transport options. Other strategies to reduce energy and carbon from commuting are the use of telecommuting, whether working from home or from local flexible office spaces. Commuter programs can also have widespread effects by reducing the number of vehicles on the road and thus reducing congestion and air emissions, improving community connections by encouraging neighbors and workers to carpool, and conserve green space by reducing the need for new parking spaces.

Implementation Strategies and Challenges

Successful commuting programs need a system-oriented design and integration with other transportation and employer programs. Government incentives for employers can take the form of tax incentives, subsidy programs, and legislative reforms (Sustainable Cities Institute, 2013). Employer-based incentive programs for low-carbon commuting can take many forms, including general travel allowance (i.e., cash award for employees who forego a parking permit), targeted and specific allowance programs (e.g., free bus or rail passes), and flexible use of allowances for services provided by many different operators. The following strategies have led to success in implementation of commuting programs:

- *Form government-business partnerships.* Employers can encourage workers to reduce the use of single occupancy vehicles, while government provides the public infrastructure to enable commuting alternatives. For example, a large local enterprise could work with the transportation agency to create special subsidized bus and rail passes for commuters.
- *Give commuters options, not limitations.* For example, an employer could offer free transit passes and provide free bike racks and shower facilities (ClifBar, in Herrera 2008). An employer might provide a carpool matching service, shared drivers (with high-efficiency, high-occupancy vehicles), or membership in a car share program to workers who need a car during the day.
- *Keep commuting programs simple and equitable.* Reward walkers and bicyclists as much as public transit riders or carpoolers, or even skateboarders. The goal is to avoid low-occupancy vehicle travel.
- *Give workers incentives that are meaningful.* Besides cash awards, prizes such as gift cards, massages, or carbon offsets can encourage participation in carbon-saving commuter programs.

Monitoring Metrics

Some suggested measures that relate specifically to this recommendation are as follows:

- Number of vehicles in circulation pre- and post-implementation (via traffic surveys)
- Change in transport modal share, including vanpools, carpools, and non-motorized transport
- Costs savings from avoided fuel and parking maintenance

Case Studies

Sustainable Commuting Programs, San Francisco, USA

<http://www.sfenvironment.org/transportation/sustainable-commuting-programs>

SF Environment is dedicated to reducing the number of single-occupant vehicles getting to and from work in San Francisco. For commuters, they help find ways to get to work and school that are faster, cheaper, and easier. For local businesses, it offers free assistance to establish programs that encourage employees to walk, bike, take transit or rideshare to work. The program offers free, customized assistance for local businesses to establish a commuter benefits program for employees. Free services for these businesses include a comprehensive employee transportation survey, analysis, and mapping to comply with the San Francisco Commuter Benefits Ordinance. For City and County of San Francisco employees, it administers the Pre-Tax Commuter Benefits program. The city also offers the Emergency Ride Home program, where anyone who works in San Francisco is eligible to be reimbursed for their ride home if an emergency arises on a day they walked, biked, rode transit or shared a ride to work. The city's Rideshare program offers a free ride matching service to help residents find carpools or vanpools heading towards the same destination.

Attributes

- Carbon Savings Potential
Medium
For some large enterprises, (e.g., Genentech biomedical firm near San Francisco) commuting emissions can be as large as 20% of the carbon footprint. Commuting programs can reduce those emissions near 5% annually (Herrera 2008).
- First Cost to Government
Low
Enterprises may find they save money, since cash incentives for alternative commuting are lower cost than providing parking spaces for employee vehicles. Workers who telecommute may give as much 60% of time saved from commuting to their employer (Sun Microsystems, in Herrera 2008).
- Speed of Implementation
<1 year
- Co-Benefits
Reduced fuel and/or electricity savings, reduced transportation costs, improved air quality, improved public health and safety

Tools and Guidance

US EPA Guidance on the Transportation Federal Green Challenge

<http://www.epa.gov/fgc/transportation.html>

Government agencies at all levels can utilize this guidance for reducing greenhouse gas and air pollutant emissions from commuting and other employee travel. Commuting measures include: reimbursement of public transportation costs for employees; choosing a building location close to public transportation; encouraging biking by providing bike rack and showers; allowing work-at-home or flexible hours to reduce employee commute trips. For other employee travel, agencies can: evaluate if videoconferencing, teleconferencing, or webinars can be used instead of physical travel; choose meeting venues near to public transportation; and reduce the number of attendees to non-critical events.

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http://www.sustainablecitiesinstitute.org/view/page.basic/class/feature.class/Lesson_Transit_Rider_Incentives

T06: Bike Share Programs

Description

A bicycle rental program, also known as a bicycle sharing system, is a service in which bicycles are made available for shared use or rental to individuals who do not own them.

Bicycle sharing systems can be divided into two general categories: "Community Bike programs" organized mostly by local community groups or non-profit organizations; and "Smart Bike programs" implemented by government agencies, sometimes in a public-private partnership. The central concept of these systems is to provide free or affordable access to bicycles for short-distance trips in an urban area as an alternative to motorized public transportation or private vehicles, thereby reducing traffic congestion, noise, air pollution and carbon emissions. Bicycle sharing systems have also been cited as a way to solve the "last mile" problem and connect users to public transit networks.

Biking is usually a good option for local short- or medium-distance travel. Conditions that favor bike share programs include: easy access to bike rental facilities, user-friendliness of the system, good weather conditions, and convenient and safe biking lanes, all of which are location-dependent variables. Other factors for success for bike rental programs include its integration into the entire transportation system and the provision of cycling infrastructure, such as marked lanes, tracks, shoulders and paths designated for use by cyclists and from which motorized traffic is generally excluded.

Implementation Strategies and Challenges

Stations. Have plenty of stations, located in close proximity to other public transport modes, for ease of use and visual advertising of the program. Cyclists should be able to rent from, and return to, any station in the system. Use modular (quick-assemble) and renewably-powered stations to reduce construction and operating costs (Vanderbilt 2013).

Access. Have an automated system, with a membership fee, and access options for those with and without credit cards or smartphones. Use smartphone apps to share information on station locations and bicycle availability (Vanderbilt 2013).

Pricing and Revenue. Utilize a sliding scale pricing system, with low or zero cost for the first 30 minutes, higher fee for longer rental, to keep bikes in circulation (Kisner 2011).

Monitoring Metrics

Some suggested measures that relate specifically to this recommendation are as follows:

- Number of bicycles in the system
- Number of bike rentals (trips per day)
- Number of stations
- Number of lost bikes and bike repairs

Case Studies

Divvy bike sharing program, Chicago, U.S.

<http://divvybikes.com/about>

Divvy is Chicago's bike sharing system with 4,000 bikes and 400 stations across the city. Intended to provide Chicagoans with an additional transportation option for getting around the city. The bike sharing system consists of a fleet of specially designed, heavy-duty, very durable bikes that are locked into a network of docking stations located throughout a city. Divvy bikes can be rented from and returned to any station in the system, creating an efficient network with many possible combinations of start and end points. With thousands of bikes at hundreds of stations, Divvy is available for use 24 hours a day, 365 days a year. The station network provides twice as many docking points as bicycles, assuring that an available dock to return bike is always nearby.

Chinese city bike sharing programs, Beijing and Guangzhou, China

http://usa.chinadaily.com.cn/epaper/2013-07/18/content_16793545.htm

Beijing will nearly double its number of bicycles for rent, to 25,000 in 2013, with plans to add more, in an attempt to cut air pollution and traffic congestion in the city. The bikes are free to rent for the first hour, then are charged at 1 yuan (16 cents) for each additional hour. The maximum expense for a full day is no more than 10 yuan, and people can only rent a bike for a maximum of three days each time. People with an ID card or passport can register at designated places and deposit 200 yuan to allow them to use their regular transport card to access the service. The Guangzhou BRT system also includes bicycle parking in its station design and a greenway parallel to the corridor, integrating the city's bike share program of nearly 5,000 bicycles and 50 bike stations.

More notable Bike Share Systems: Copenhagen, Amsterdam, London, Paris, Montreal, Washington DC.

Attributes

- Carbon Savings Potential
Low
The carbon savings can be calculated based on avoided vehicle trips.
- First Cost to Government
Low
- Speed of Implementation
1-3 years
- Co-Benefits
Supports other measures for low-carbon transport modes; reduces traffic congestion and enhances urban appeal; saves fuel and/or electricity; improves air quality, improves public health.

Tools and Guidance

Integrating Bike Share Programs into a Sustainable Transportation System

The paper summarizes the concept, operation and benefits of bike sharing program, and provide cases in Denver, Washington D.C., Minneapolis, Buffalo.

http://c133311.r11.cf0.rackcdn.com/Brief_BikeShare_2011.pdf

Bike-sharing: History, Impacts, Models of Provision, and Future

The paper discusses the history of bike-sharing from the early 1st generation program to present day 3rd generation programs. Included are a detailed examination of models of provision, with benefits and detriments of each, and a description of capital and operating costs. The paper concludes with a look into the future through discussion about what a 4th generation bike-sharing program could be.

<http://www.nctr.usf.edu/jpt/pdf/JPT12-4DeMaio.pdf>

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T07: Improved Bicycle Path Networks

Description

As a viable alternative to short car trips, bicycling avoids the carbon and other air pollutant emissions from driving, along with providing additional benefits of reducing traffic congestion and improving health. One important policy for increasing the use of bicycles is creating bike-friendly networks throughout a city. Specific design considerations include: providing designated bike lanes on streets, limiting automobile access to bike areas and lanes, and separating pedestrian and bike areas with barriers to maximize safety. Providing secure bike parking in buildings, on streets and at transit stations also encourages cycling. The establishment of government-funded cycling demonstration towns and cities, such as those in the UK, can also increase awareness and use of cycling for personal transport.

Bicycling paths can be divided into two categories: physically separated by barriers, parking or posts from other (especially motor vehicle) traffic, or segregation with painted markings. Bike lanes and road shoulders demarcated by paint are quite common in many European and American cities. Segregated cycle facilities demarcated by barriers, posts or boulevards are quite common in some European countries such as the Netherlands, Denmark and Germany. They are also increasingly being installed in other major cities such as New York City, Melbourne, Vancouver, Ottawa and San Francisco. Montreal and Davis, California are among the North American cities that have had segregated cycle facilities with barriers for several decades.

Implementation Strategies and Challenges

Implementation Activity	Description
Integrate Bicycle Networks in Transport Planning	Bicycle networks have the highest utilization (and greatest carbon savings) when prioritized and integrated with a city's transport planning. Emphasizing bicycle path infrastructure in housing and commercial developments is key.
Prioritize Transport Investment in Cycling Routes	The building and maintenance of bicycle paths are a lower-cost transport investment compared to motorized modes. Low-income community members rely more heavily on non-motorized transport. Investing in bicycle path networks enhances social equity in mobility, as well as saving energy and carbon and money.
Public Engagement	Bicycle path networks can be very visible and appealing projects, and input from the public about desirable routes and features can contribute to the design.

Monitoring Metrics

Some suggested measures that relate specifically to this recommendation are as follows:

- The share of bicycle lanes and paths in total road length
- The length of designated bicycling paths (marked paths, bicycle-only lanes, etc.)
- Bicycling mode share of total transport activity

Case Studies

Cycle path network study in Gdansk, Poland

http://www.eltis.org/index.php?id=13&study_id=3269

The Gdansk City Development department, in consultation with the Active Mobility Team, City Cyclists' Attorney and citizens, has developed a target network of bicycle routes, integrated with the city's public transport and parking systems. The project is the response of city authorities to the needs of citizens involved in everyday bicycle use. The aim is to create coherent conditions for safe and comfortable bicycle use in the Gdansk area. The measures involved cover the requirements of all bicycle users, including commuters and recreational cyclists. The initiative will form the basis for implementation of city bicycle policy. The initiative covers integration of the following elements: Main and local bicycle routes; Recreational bicycle routes; Calmed traffic zones; Network of strategic bicycle parking locations; Public transport; and City bicycle rental system. An important part of the project is consultation with citizens. The idea is to consider all ideas and solutions provided by the public and by non-government organizations, in order to create a more friendly and functional project.

New York City Bicycle Network Development

<http://www.nyc.gov/html/dcp/html/bike/home.shtml>

The goal of the Department of City Planning, New York City Department of Transportation, and the Department of Parks and Recreation's Bicycle Network Development program is to reduce congestion by promoting cycling in New York City. As a joint project between the city's three different departments and with funding through a federal program to mitigate air quality from congestion, this program aims to implement and maintain New York City's on- and off-street bicycle network; improve cycling safety; improve bicycle access on bridges and mass transit; and institutionalize cycling in public and private organizations. The program is focused on implementing a city-wide network of bicycle lanes and paths in all five boroughs, and recent accomplishments towards this goal have included the identification of a 900-mile bicycle network, the development of a New York City Bicycle Master Plan with proposals for new projects, a comprehensive bicycle program and guidelines for design of bicycle facilities as well as a cycling map that shows existing and planned bicycle networks.

Dedicated cycle network, Bogota, Colombia

C40 Cities. 2010. "Bogota, Colombia: Bogota's CicloRuta is one of the most comprehensive cycling systems in the world." Online:

http://www.c40cities.org/bestpractices/transport/bogota_cycling.jsp

CicloRutas is considered a unique cycling network where design has taken the topography of the city into consideration in order to create maximum flow and function (manmade and natural features, hills, waterways, parklands, essential facilities). In a period of just 7 years, following an investment of USD 50 million, the use of bicycles on the network increased by more than 268%. CicloRutas plays an important role for lower income groups, as more than 23% of the trips made by the lowest income group in the city are by walking or by bike. The development of CicloRutas has also helped to recover public space along riverbanks and wetlands, as for many years the city's wetlands were occupied by illegal settlements.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced fuel and/or electricity savings, improved air quality, improved public health and safety, enhanced vitality of public spaces

Tools and Guidance

Sustrans. 2007. Technical guidelines for the development of cycle facilities.

A series of guidance documents for professionals on the details of bicycle network design. Available online from <http://www.sustrans.org.uk/resources/design-and-construction/technical-guidelines>

Transport for London. 2010. London Cycling Design Standards.

A guidance document for designing to reduce barriers to cycling and support road safety targets. Available online from <http://www.tfl.gov.uk/businessandpartners/publications/2766.aspx>

San Francisco Bicycle Plan

<http://www.sfmta.com/cms/bproj/bikeplan.htm>

U.S. Federal Highway Administration, Office of Human Environment: Bicycle & Pedestrian Program:

http://www.fhwa.dot.gov/environment/bicycle_pedestrian/index.cfm

T08: Complete Streets

Description

Multimodal Streets, also called “Complete Streets,” promote a holistic approach to urban transportation. Shifting away from an emphasis on private vehicle traffic, Complete Streets aim to balance multiple transport modes and create appealing urban spaces (Vance 2013). Among multiple modes of transport, Complete Streets give first priority to pedestrians, because all transportation and business begins and ends with people, on foot, (Chicago DOT 2013). Streets that favor non-motorized and public transportation reduce energy consumption and greenhouse gas emissions, helping a city to achieve low-carbon development. Complete Streets are one component of implementing Integrated Transportation Planning.

Design features of Complete Streets include signage and lane striping, raised crosswalks and pedestrian control signals, bus pull-outs and traffic calming measures (New York DOT 2013). Rather than huge multi-lane two-way intersections, pairings (couplets) of one-way streets can provide easier crossing for pedestrians while still facilitating traffic flow of vehicles (SFMTA, 2011). This strategy is used by densely populated cities such as San Francisco, New York City, Toronto, Seattle and Denver. Complete Streets have sidewalks that easily access retail, restaurants, and other pedestrian services – not forbidding concrete building fronts along barren super-blocks (Calthorpe Associates, 2010). Trees and vegetation, shaded entrance ways, umbrellas and benches all contribute to pedestrian appeal and safety – and reduced transport pollution (Russo and Grant 2013).

Implementation Strategies and Challenges

Implementation Activity	Description
Strong Leadership	Strong leadership in the mayor’s office can speed implementation by aligning the work of local government agencies. Small projects can be done first to gain experience, then larger projects with larger potential for modal shift and emission savings.
Budget Savings	Save budget by implementing complete streets upgrades during planned maintenance or repair of streets. This low-cost strategy complements other low-carbon transportation measures.
Public Engagement	Complete Streets can be very visible and appealing projects, and input from the public (on location of safer street crossings and bus stops, benches and trees) can contribute to the design. Consultation, distribution of leaflets, advertisements on buses, city-wide posters, and multiple press releases can ease implementation with all stakeholders.

Monitoring Metrics

Some suggested measures that relate specifically to this recommendation are as follows (Dock et al. 2012; NYC DOT 2012):

- length of streets re-designed as Complete Streets
- Improvement in bus speed and bus ridership on Complete Streets
- Greenhouse Gas emission savings resulting from reduced congestion on Complete Streets
- Accessibility Score (e.g., number of destinations within a 15-minute walk from a property parcel)
- Changes in VMT per household or VMT per employee, as a Sustainability metric
- Multi-model Level of Service (MMLOS), as a Livability metric

Case Studies

Sustainable Streets, New York City

<http://www.nyc.gov/html/dot/html/about/stratplan.shtml> ; Russo and Grant 2013; Gordon-Koven 2012.

New York City is a leader in implementing multi-modal streets in the U.S. – and in measuring the benefits of that effort. With city agencies answering directly to Mayor Bloomberg, the Mayor gave Transportation Commissioner Sadik-Khan the “green light” to proceed. The Commissioner gave attention to both technical innovation and public communication. NYC started with small pilot projects to make streets more humane (paint, chairs, signal changes), learned from them, and scaled up to bigger projects of converting automobile lanes to bus rapid transit lanes and physically separated bicycle lanes. As a result, traffic congestion was reduced on the improved multi-modal streets (10% - 50%), bus speed and ridership improved (10% - 50%), and local businesses saw increased sales (as much as 50%).

Complete Streets - Memphis, Tennessee

<http://www.streetsblog.org/category/issues-campaigns/complete-streets/>

The Complete Streets experience in Memphis (population 655,000) is pragmatic and publicly engaging. A campaign in 2010 to revitalize the Broad Avenue neighborhood led to 25 new businesses and a vibrant commercial area. The sidewalk vendors, public street furniture, bike lanes, and street calming were so successful that they stayed beyond the campaign. This positive experience in street re-design led to the passing of a Complete Streets city policy. Efforts to incorporate bike lanes, improved pedestrian features, and better transit access were done with very little budget, by making the changes when street resurfacing was already planned. With this approach, over 50 miles of bike lanes were installed within 2 years. The Complete Streets improvements will also have an important health benefit by encouraging walking and bicycling, an essential public health measure for a population with 60% obesity.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
1-3 years

- Co-Benefits
Reduced fuel and/or electricity savings, improved air quality, improved public health and safety, enhanced vitality of urban business and social spaces

Tools and Guidance

Chicago Department of Transportation (DOT). 2013. Complete Streets Chicago: Design Guidelines.

Online: <http://chicagocompletestreets.org/> and

<http://www.cityofchicago.org/content/dam/city/depts/cdot/Complete%20Streets/CompleteStreetsGuidelines.pdf>

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T09: Public Transit Infrastructure: Light Rail , BRT, and Buses

Description

Policies to reduce transport CO₂ emissions through public transportation focus on increasing the use of public transportation – light rail, Bus Rapid Transit (BRT) and buses – as well as promoting a shift towards more efficient and low carbon bus fleets.

Urban light rail is best suited to cities with high population density. The European experience has shown that in cities with populations of over ten million, urban light-rail transit can have important effects reducing CO₂ emissions and improving the efficiency of urban transport. Ideally, urban light rail transit should be initiated in cities where it can reach a capacity of 10,000 or 20,000 persons per hour per direction (pphpd), with the greatest impact if capacity can exceed 35,000 pphpd.

Bus rapid transit (BRT) in dense cities can provide frequent, fast and direct services to easily accessible locations with low costs and flexible routes. This requires establishing high-capacity, high-speed transit corridors and minimizing the number of transfers needed while ensuring the rapid buses are part of an integrated multi-modal system (EF 2011). In China, Guangzhou introduced its BRT in February 2010 and it is integrated with bike lanes, metro and other local bus routes. The Guangzhou BRT now moves 27,000 passengers/hour/direction during peak times (EF 2011).

Besides increasing the utilization of buses through improved access and quality, CO₂ emissions can also be reduced directly through increased fuel efficiency and greater penetration of hybrid, electric, and fuel cell technology. The fuel efficiency of bus fleets can be improved by encouraging fuel-efficient operation through greater passenger loads as more passengers translate into lower emissions per passenger. Incentivizing the adoption of low carbon buses will achieve carbon savings. Low carbon buses can play a greater role in the bus fleet through mandating the purchase of newer hybrid buses to replace older inefficient buses (e.g. San Francisco MUNI) or by providing incentives for hybrid buses.

Implementation Strategies

Policies that support light rail transit emphasize increasing the proportion of light rail transit in total transport activity in the city transport planning and development. For example, Chinese mega-cities such as Beijing and Shanghai have set a long-term development target of more than 1000 km of light rail tracks. In the process of developing local urban development plans, governments should consider light rail transit and take steps to incorporate it into transport and infrastructure planning and development.

To encourage the development of light rail and bus systems, funding for public transit infrastructure should also be prioritized over funding for private vehicle infrastructure. Funds gathered from traffic reduction measures (e.g., license fees, congestion pricing) can be ear-marked for public transit infrastructure such as the establishment of urban light rail or BRTs, as well as for pedestrians and bicyclist infrastructure. The construction of light rail transit infrastructure should also be coordinated with real estate and business district development to ensure integrated transport planning and implementation.

Monitoring Metrics

Metrics for monitoring the performance of public transit infrastructure include:

- Public transport passenger activity (e.g., passenger-kilometers, trips)
- Mode share of people travelling by light rail, BRT, and buses in area or city.
- Total length and density of light rail, BRT, and buses
- Investment in light rail, BRT, and buses
- Maintenance funds and revenue income for each public transit mode

Case Studies

BRT system, Bogota, Colombia

Source: ESMAP (2009). "Good practices in city energy efficiency: Bogota, Colombia - Bus Rapid Transit for Urban Transport Energy", available online from http://esmap.org/esmap/sites/esmap.org/files/Bogota_Case_Study_020310.pdf

With the completion of its first two phases, the TransMilenio BRT system serves about 1.5 million passengers every day and has reduced city-wide fuel consumption by 47%. Key success factors for this BRT system have included: city-wide comprehensive planning of infrastructure, use of state-of-the-art technologies, implementation of a variety of design features to accommodate high volumes of passengers, and the use of a simple single price faring system. The project's capital cost totaled USD 240 million. It does not require subsidies to operate as its operational costs are fully covered by fares. The system is managed by a company that was set up by the Mayor, but runs independently from the city administration. While the company is in charge of all planning, maintenance and construction of infrastructure as well as organizing the schedules of bus services, buses and drivers are contracted through private firms, resulting in a complex but innovative management structure.

BRT system, Guangzhou

Integration of public transit with walking and biking is the key to low-carbon transportation in Guangzhou. After years of coordinated planning, in February 2010, China's third-largest city opened 22.5-kilometers of Bus Rapid Transit (BRT), the first BRT in Asia connected with the metro rail system.⁶¹ The Guangzhou BRT system also includes bicycle parking in its station design and a greenway parallel to the corridor, integrating the city's bike share program of nearly 5,000 bicycles and 50 bike stations.⁶² Within 18 months of opening the BRT, Guangzhou achieved the world's highest rate of BRT passengers—805,000 daily boardings—carrying more passengers per hour than any mainland Chinese metro outside of Beijing, and tripling the capacity reached by other BRT in Asia.⁶³ The efficiency

⁶¹ Institute for Transportation & Development Policy, History of ITDP; Hughes and Zhu, 2011. <http://www.itdp.org/>

⁶² National Geographic, 2011; ITDP Sustainable Transport Award.

⁶³ Hughes and Zhu, 2011; ITDP News, <http://www.itdp.org/news/guangzhou-brt-reduces-co2-emissions-by-86000-tonnes-annually>

improvements from BRT have reduced travel time for bus riders and motorists along the route by 29% and 20%, respectively. The fuel savings will in turn save 86,000 t CO₂e annually.⁶⁴

Attributes

- Carbon Saving Potential
High
- First Cost to Government
Medium
- Speed of Implementation
> 3 years

Shifting passengers from low-occupancy vehicles to public transit results in high energy and CO₂ savings. Bus and rail transport can save close to 80% of vehicle emissions per passenger kilometer. In the US, 17 transit-oriented development projects in five medium- to large-sized metropolitan areas showed a 44% reduction in vehicle trips, compared to typical patterns of car-focused development.⁶⁵

Among public transit infrastructure choices, buses have somewhat higher emissions per passenger kilometer than rail, yet their lower capital costs make busses an affordable public transit options. Electric rail, with its higher operating efficiency (yet higher capital cost), is appealing for the highest-density cities that will have sufficient fare revenue to recoup the investment. BRT offers the benefits of both: dedicated bus lanes gain improved efficiency at a lower cost than rail. To ensure sufficient revenue, transit agencies must carry out smooth operation, make easy connections and payment systems, and share information with the ridership.

Hybrid buses can reduce CO₂ emissions by 30-40% compared to conventional buses, along with 95% less particulate matter and 40% less NO_x (SFMTA 2011).

Tools and Guidance

WRI EMBARQ BRT Simulator

<http://www.embarq.org/en/project/embarq-software-BRT-simulator>

The EMBARQ BRT Simulator is a computer software tool to tests improves the design of proposed bus rapid transit systems. The software evaluates traffic flows and detects potential problems before any real construction begins, which could help cities save valuable time and money during the planning process.

Global BRT Data

⁶⁴ Hughes and Zhu, 2011.

⁶⁵ SFMTA, 2011; Cervero, 2009.

<http://brtdata.org/>

The goal of BRTdata.org is an online data source to improve the sustainable transport community's access to reliable and current data about the BRT and bus corridors currently in operation. It aims to improve the quality and impact of the industry by opening up access to data about the design, performance and cost of these systems. The platform provides a convenient repository of data from a variety of sources including researchers, transit agencies, municipalities and NGOs.

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T10: Congestion Charges and Road Pricing

Description

Congestion charges are intended to restrict access of selected vehicle types, usually private vehicles, into large urban areas during the most congested times of the day by raising the cost of driving. Often implemented to improve traffic flow and reduce air pollution in a city, congestion charges and road pricing also discourage carbon-intensive private vehicles and reduce idling in traffic, which in turn saves fuel and carbon.

Congestion charges can be considered a market-based mechanism for influencing driver behavior, which looks to capture the external social and environmental cost of vehicle travel during congested periods of the day. By imposing an additional cost through congestion charge, travelers are provided economic incentives to travel during off-peak hours, through non-congested routes or through other modes of transportation such as public transit. The form of congestion charges varies, and may range from a flat fee for travel during peak traffic hours to sophisticated electronic road pricing with variable rates. Another form of congestion pricing is toll charges that allow single occupant vehicles to travel on express, high-occupancy lanes during peak travel hours.

Congestion pricing measures have been adopted by different countries and states, including Singapore, Norway, the U.S. and London in the UK. The pricing schemes differ, with daily charges incurred by motorists in Singapore and the UK while the U.S. and Norway charge a toll per passage. Specifically, Norway has charges for toll rings while the U.S. has high occupancy toll lanes in Maryland, Texas, and Minnesota. By paying a toll charge, a single occupant vehicle can travel on express high-occupancy lanes. In London, vehicles entering a specific downtown zone were required to pay a congestion charge ranging from £9 to £12 (with lower charges for paying a day ahead or automatically) between the peak travel hours on weekdays (Transport for London 2011). In Singapore, the pricing scheme changed in 1998 from per day charges to per entry charges using electronic road pricing or electronic toll collection. The electronic road pricing consists of a complex pricing scheme where the charges vary by vehicle, time of day and point of entry and the prices are reviewed every three months (Santos et al. 2004).

Implementation Strategies and Challenges

Strategies for successfully implementing congestion charges lie in three areas: technical implementation, schematic layout and public acceptance. For the technical implementation of congestion charges, there needs a strategic choice of the appropriate charging technologies. (e.g., manual toll collectors versus electronic pricing). The technological choice may depend on the design requirements of the urban surroundings, the frequency of occasional users, compliance enforcement and the overall system costs. In terms of the pricing scheme layout, factors that need to be determined include the geographical perimeter for charging, the price level and the legal nature of the charge. Lastly, successful implementation of congestion charges will depend on public acceptance of the charge, which in turn

influenced by public perception of congestion problem, how the revenue is used, the adoption of complementary measures, and the transparency and accountability of the pricing scheme.

Monitoring Metrics

Metrics related to congestion charges and road pricing include:

- Travel activity and congestion prior to and after implementation of the congestion charge
- Congestion charge revenue
- Changes in transport modal shares

Case Studies

Congestion charge, Stockholm, Sweden

Source: C40 Cities (2010). "Stockholm: Congestion charge", available online from http://www.c40cities.org/bestpractices/transport/stockholm_congestion.jsp

Stockholm's congestion charge was introduced in 2006 with an initial six-month trial. In Stockholm, drivers are charged every time they enter into and out of the congestion zone ('crossing the cordon') which encompasses the city centre. The charge varies from 1 to 2 Euros (per direction) according to the time of entry, and high definition cameras with Automated Number Plate Recognition software are used to register vehicles. Drivers are automatically billed, usually by 7pm the same day. Measures which have helped address perceived implementation barriers have included: a simple and user-friendly zone charging structure; a simplified payment process; and a consideration of seasonal traffic variations to enhance public opinion (e.g., the month of July - a key holiday in Sweden - is exempt from the charge).

Congestion charge, London, UK

Sources: ESMAP (2011). "Good Practices in City Energy Efficiency, London, UK: Congestion Charges for Urban Transport" available online from <http://www.esmap.org/esmap/node/1279>;

In February 2003, London introduced a daily congestion fee for vehicles travelling in the city's central district during weekdays. This fee was meant to ease traffic congestion, improve travel time and reliability, and make central London more attractive to businesses and visitors. This charge is based on a flat-rate fee applicable during weekdays and normal working hours and has been effective because it is easy to understand and implement, and is also reflective of the nature of congestion in London (consistent throughout the day). Video cameras at entry points to the zone and mobile units within the zone register vehicles which enter the zone by means of automatic number plate recognition technology.

Payments are made electronically on the day of entry into the zone. There are discounts for monthly/annual payments, as well as 90% discounts for residents within the priced area. As a measure to meet the predicted rise in demand for public transportation, the city authority invested in the pre-implementation expansion of bus.

According to the city's analysis, the program has largely met its objectives. After four years of operation, traffic entering the charge zone was reduced by 21%; congestion, measured as a travel rate (minutes per kilometer), was 8% lower; and annual fuel consumption fell by approximately 44-48 million liters or about 3%. These reductions translated into 110,000-120,000 tons of carbon dioxide (CO₂) reductions annually, a 112 ton reduction in nitrogen oxides (NO_x), an eight-ton reduction in particulate matter (PM₁₀), and some 250 fewer accidents. In terms of the program cost-effectiveness, the identified benefits exceeded the costs by more than 50 percent. The scheme also brought a steady net revenue stream for transport improvements, including the reinvestment of 80% of the surplus revenue in improving public bus operations and infrastructure. Key elements of success in the city's program design included: technical design, public consultation, project management, information campaign and impact monitoring.

Congestion charge, Singapore

Source: Singapore Land Transport Authority (2002). "Road Pricing - Singapore's Experience", available online from http://www.imprint-eu.org/public/Papers/IMPRINT3_chin.pdf

Implemented first in 1975, Singapore's congestion pricing initiative has evolved from a manual scheme based on paper permits and applicable during the morning peak period only to an electronic version that operates throughout the day. The City Authority enacted a pre-implementation expansion of the bus fleet to meet the predicted rise in demand and also developed new Park-and-Ride facilities to support the scheme. Results show that weekday traffic entering the Restricted Zone has been reduced by 24%, decreasing from 271,000 to 206,000 vehicles per day. Annual revenues are approximately 11 times the initial capital costs and annual operating costs, giving the program a significant payback.

Attributes

- Carbon Savings Potential
Medium
- First Cost to Government
Low
- Speed of Implementation
1-3 years
- Co-Benefits

Reduced carbon emissions; Improved air quality; Enhanced public health & safety; Reduced traffic congestion; Revenue stream to support other low-carbon transportation measures.

Tools and Guidance

OECD Transport Research Centre and International Transport Forum. 2010. *Implementing Congestion Charges*. Paris: OECD/International Transport Forum. http://www.oecd-ilibrary.org/transport/implementing-congestion-charges_9789282102855-en

US Department of Transportation (2009). "Value Pricing Pilot Program Planning and Decision Making Tools" A series of tools for estimating the impacts of congestion pricing strategies. Available online from http://www.ops.fhwa.dot.gov/tolling_pricing/value_pricing/tools/index.htm

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Santos, G., W.W. Li, and W.T.H. Koh. 2004. "Transport Policies in Singapore." *Research in Transportation Economics*. 9: 209-235.

Transport for London. 2011. "Congestion Charging." Available online: <http://www.tfl.gov.uk/roadusers/congestioncharging/default.aspx>

T11: Parking Fees and Measures

Description

Parking is the resting place for private vehicles – a highly carbon –intensive mode of transportation. Policies that discourage parking help to remove private motor vehicles from city roadways and thereby reduce traffic congestion. Fewer private vehicles and less traffic congestion in turn reduces fuel use and vehicle-related carbon and air pollutant emissions. City officials can introduce a variety of measures to alleviate parking challenges and the related impacts on downtown congestion. Planning measures that restrict parking availability as well as variable parking fees that remove incentives for private parking – particularly in the busy downtown core areas - help discourage private car use and instead, motivate the use of more sustainable modes of transport such as public transit, bicycling, and walking.

Implementation Strategies and Challenges

Implementation Activity	Description
Planning measures	The City Authority introduces planning measures which determine car parking provision for residential and office developments. Introducing maximum parking allowances with low car-to-unit ratios discourages private-car acquisition and use. Such measures do not affect the existing parking provision, however, and so need to be supported by additional measures. While areas of intervention can be defined, larger coverage is more effective as it has less potential to overwhelm surrounding areas. A gradient approach solves this by making requirements less stringent from the center to the periphery. These measures safeguard energy use and efficiency in design and thereby bear no immediate cost to the city authority. See London case study for further details.
Parking fees	The City Authority charges for on-street parking. Implementing a charging regime for car parking and formalizing parking arrangements will enable the parking stock to be controlled and generate a revenue stream for sustainable transport measures. This type of approach requires a supporting system for enforcement, e.g. traffic wardens who issue fines to perpetrators, and are politically very sensitive measures. See San Francisco case study for further details.
Park & Ride facilities	The City Authority promotes multimodality by providing Park & Ride locations at key interchanges. By linking parking to public transport use, the commuting needs of non-downtown residents are considered. The success of Park & Ride is linked to availability of public transport and unavailability of cheap parking in central locations. The perceived cost should be lower than that of driving the entire way. Measures of this kind often require major capital investment in infrastructure by the city authority with respect to 'Park & Ride' locations on the periphery of the city, bus terminals and additional buses. See Oxford case study for further details. Complementary implementation activity: Planning measures

Monitoring Metrics

Some suggested metrics that relate specifically to this recommendation are as follows:

- Total parking stock and usage (via surveys)
- Total number of vehicles in circulation (via traffic surveys and traffic counters)
- Transport modal share
- Average length of trips
- Rate of growth of car registration

Case Studies

Parking Standards, London Plan, London, UK

London (2010). "Chapter 6: Transport" in The London Plan, available from <http://www.london.gov.uk/shaping-london/london-plan/docs/chapter6.pdf> pp.160-161.

The London Plan establishes maximum parking guidelines for residential development. It stipulates that all developments in areas of good public transport accessibility should aim for significantly less than 1 parking space per unit. The main challenge continues to consist of ensuring that these standards are supported other measures which reduce car dependency, both within the development and in the surrounding area, e.g. improved and increased public transportation accessibility.

Demand-Responsive SFpark Pricing, San Francisco, USA

Institute for Transportation and Development Policy (2010) "U.S. Parking Policies: An Overview of Management Strategies", available online from http://www.itdp.org/documents/ITDP_US_Parking_Report.pdf

San Francisco Municipal Transit Agency's (SFMTA) installed new electronic, multi-space meters in 2009 and activated parking spot sensors attached to the pavement in 2010 under its new SFpark program. The aim of SFpark is to use demand-responsive pricing to help redistribute the demand for parking, with possible hourly rates ranging from \$0.25 to a maximum of \$6. Rates may vary by block, time of day and day of week, and can be adjusted by reducing a maximum of \$0.50 per hour or by increasing \$0.25 per hour within a month. SFpark is based on a Data Management System which sorts a significant amount of data collected from the networked array of remote sensors in all 6,000 parking spots. These wireless sensors can detect whether a spot is occupied by a vehicle and report parking occupancy information in real time to a central computer. The project will produce valuable data about the effect of meter pricing on occupancy. The project currently covers 5500 of San Francisco's 25,000 metered curbside parking spots in eight pilot neighborhoods as well as 14 of the city's 20 public parking garages.

Distance-based Parking Fees, Aspen, US

Source: Victoria Transport Policy Institute (2010). "Parking Pricing Implementation Guidelines", available online from <http://www.vtpi.org/parkpricing.pdf>

In order to alleviate the high levels of congestion in downtown Aspen and the subsequent effects of the "ninety-minute shuffle" where locals and downtown commuters moved their vehicles every 90 minutes to avoid a parking ticket, the city introduced charges for on-street parking using multi-space meters in 1995. Parking fees were set based on the location, with the highest rates in the city center and declining rates with increasing distance from the core. The city held a marketing campaign to introduce the meters to motorists, including the distribution of one free prepaid parking meter card to each resident to help familiarize them with the system. Motorists were also allowed one free parking violation.

Park-and-Ride, Oxford, United Kingdom

Oxford City Council (2009). "Park and Ride Transfer", available online from http://www.oxford.gov.uk/PageRender/decTS/Park_and_Ride_occw.htm

Oxford city has five Park-and-Ride sites serving the city's shoppers, visitors and commuters. Parking fees for the Park-and Ride sites vary by location, with daily and weekly rates charged for three sites and rates based on duration charged for the other two sites (e.g., free for the first 11 hours, 3 GBP for every 24 hours for up to 72 hours). For convenience, these sites use a ticketless payment system featuring automatic number plate recognition cameras. The management of two of the five Park-and-Ride sites was transferred to Oxfordshire county, resulting in savings of 250,000 GBP per year for the city administration from economies of scale and the sharing of the cost of providing the service with taxpayers across the County, and not just those in the city.

Attributes

- Carbon Savings Potential
Medium
- First Cost to Government
Low
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced carbon emissions; Improved air quality; Enhanced public health & safety; Reduced traffic congestion; Revenue stream to support other low-carbon transportation measures.

Tools and Guidance

Victoria Transport Policy Institute (2010). "Parking Management: Strategies, Evaluation and Planning" A comprehensive guidance document for planning and implementation of parking management strategies. Available online from http://www.vtpi.org/park_man.pdf

Victoria Transport Policy Institute (2010). "Parking Pricing Implementation Guidelines" A guidance document for implementation of parking pricing with details on overcoming common obstacles. Available online from <http://www.vtpi.org/parkpricing.pdf>

Spillar, R. (1997). "A Comprehensive Planning and Design Manual for Park-and-Ride Facilities" A guidance document for the planning and design of Park-and-Ride facilities. Available online from <http://www.pbworld.com/library/fellowship/spillar>

T12: Vehicle License Policies

Description

Policies to control the circulation of private vehicles via their license plates can contribute to carbon savings by reducing the use of this high-carbon transport mode. Vehicle license policies may control the total number of vehicles registered in a city, or they may control the operation of vehicles based on their license plate number. These policies set quotas for private motor vehicles in order to restrict the number of vehicle registrations over a given period of time. Registration limits discourage potential drivers from buying a new vehicle and can also be used to reduce the total number of vehicles in circulation. By limiting car ownership, license control policies are intended to encourage alternative modes of transportation, which in turn will help increase the viability of low-carbon transport modes, such as public transit patronage. Removing vehicles from circulation (in total, or on particular days and locations) also helps reduce congestion, fuel use and vehicle-related emissions and reduces the need for road space.

Implementation Strategies and Challenges

Implementation Activity	Description
Blanket bans	The City Authority imposes blanket bans on new vehicle registrations. Possible types of blanket bans include vehicle-type bans which exclude entire vehicle categories from circulation; or license plate bans which bans a certain number of plates from circulation. A weakness of license plate bans is that they tend to result in wealthier residents purchasing second cars, which not only reduces the effectiveness of the policy but also results in wealth inequalities.
License Rationing	The City Authority rations permits for vehicle licenses. The establishment of quotas for private vehicles allows for only a certain number of vehicle registrations over a given period of time. However, as demand for cars tends to be inelastic, this often results in very high purchase prices for the licenses, which disincentivizes new car purchases but may also favor the wealthy which can afford to purchase more expensive vehicles.
License Circulation Restrictions	Use of city-center roadways is restricted to a particular range of license plate numbers on particular days. Violators can be easily spotted by their license plate number, though roadway cameras and additional compliance staff may be needed to enforce the restrictions. This approach allows the ownership of vehicles but restricts their operation in the most congested locations.
Civic initiatives	The City Authority sanctions and encourages 'no-driving days' to educate and lead by example. Participation in these initiatives is voluntary, however, and therefore not enforceable.

Monitoring Metrics

Some suggested metrics that relate specifically to this recommendation are as follows:

- The total number of vehicles in circulation pre- and post-implementation
- New vehicle purchases pre- and post-implementation.
- Changes in transport modal shares
- Total number of and growth rate of new vehicle registrations

Case Studies

Vehicle bans: Motorcycle ban, Guangzhou, China

Institute for Transportation and Development Policy (2008). "Case study: motorcycles in Guangzhou", available online from <http://www.itdp.org/documents/Guangzhou%20Case%20Studies%20-%20Motorcycles%2015-Sep-08.pdf>

Motorcycles have been completely banned in the City of Guangzhou. The ban was implemented in phases, beginning with a moratorium on new licenses, extending to various roads and time periods. Gradual implementation has been crucial to allow time for the public to adapt, and increase in the supply of additional infrastructure and services have helped support the induced modal shift. Many motorbike riders have shifted to bicycles and buses, and cycle rickshaws have also emerged as a popular substitute. Road accidents have dropped by 40% since the initial implementation of the ban.

License plate circulation restriction by auctioning and lottery: Guangzhou, Shanghai, Beijing, China

"Congested Chinese cities seek best way to issue license plates." WantChinaTimes.com. 2012.9.18.

Shanghai's practice of auctioning license plates has controlled the number of automobiles near 2 million and kept traffic flowing, although only the wealthy can afford the auction. In contrast, Beijing's past policy of allowing access to certain license numbers on certain days did not sufficiently control traffic, and roads jammed with more than 5 million cars. Guangzhou has learned from these experiences, and is implementing a combination of auction and lottery for automobile licenses. This approach will reduce traffic, save CO₂, and enable more equitable access to licenses. Several Chinese cities are now exploring the use of license restrictions as well.

Vehicle Quota, Singapore, Singapore

Sustainable Urban Transport Project (2010). "The Vehicle Quota System in Singapore", available online from http://www.sutp.org/index2.php?option=com_content&do_pdf=1&id=1582

Singapore limits the total number of new vehicles allowed for registration each year with the goal of obtaining a target rate of growth in the total motor vehicle population. In practice, the annual quota is allocated in portions to the public each month in a sealed bid uniform price auction. Potential buyers need to bid for a non-transferable license, which entitles them to own a vehicle for a fixed number of ten years. The scheme had to be modified soon after implementation to safeguard against speculative

action. More specifically, the licenses were initially transferable and within the first two months of the first round of release, 20% changed hands in "buy and sell" transactions with speculators making sizable profits of up to \$5,000. As the rationing system does not control annual mileage, the success of the rationed registration in limiting vehicle usage has been dependent on support from other traffic restrictions, such as high road tolls, parking fees, and electronic road pricing.

Attributes

- Carbon Savings Potential
Medium
- First Cost to Government
Low
- Speed of Implementation
<1 year
- Co-Benefits
Reduced carbon emissions; Improved air quality; Enhanced public health & safety; Reduced traffic congestion; Revenue stream to support other low-carbon transportation measures.

Compared to other policies that reduce private vehicle traffic and congestion, license control policies are speedier to implement, as little infrastructure is needed. Consideration should be given to social equity concerns by including a lottery component (not only and auction) for license registration. Revenue should be invested in public transit, bicycling and pedestrian programs, to ensure that city residents have an alternative to private vehicles.

Tools and Guidance

Victoria Transport Policy Institute. "Vehicle Restrictions." www.vtpi.org/tdm/tdm33.htm

T13: Public Outreach on Transport

Description

To complement government action on low-carbon transportation infrastructure, public outreach programs engage the citizenry and exchange information for improved utilization of transport modes. Public outreach campaigns and programs on transport may cover education on priorities for low-carbon transport modes, enhanced services for cycling and public transit, specific vehicle technologies, and methods to improve fuel economy and driving behaviors. For example, prior to the launch of the new Rea Vaya bus rapid transit (BRT) system, the city of Johannesburg set up an information kiosk in a large shopping center along the future route to educate the public and answer questions (EMBARQ 2011). As another example, educating drivers about energy-saving driving techniques and patterns can help reduce vehicle emission by 10-15%, as demonstrated by the UK's Eco-Driving program (UK Road Safety Ltd. 2011). In addition, freight transport and logistics industries can also promote behavioral change among truck drivers through training programs and guidelines. In the EU, the rail and ocean freight industry has initiated a project to promote optimal driving behaviors by making recommendations based on the effectiveness of fuel consumption and emission reductions. These education campaigns and programs can help increase safety awareness, as well as reduce fuel costs and road emissions.

Implementation Strategies and Challenges

Carry out public info campaigns on streets and public transit hubs, as well as in schools, housing developments and workplaces. Highlight: (1) priorities for low-carbon transport modes: walking, bicycling, and public transit; and (2) the contribution of low-carbon transport to better air quality and public health.

Good design and a strong 'brand identity' are important to achieve strong public utilization of low-carbon transport infrastructure. Automobile manufacturers invest heavily in design of advertising campaigns; low-carbon transport would benefit from greater public campaigns (EMBARQ 2011). Transport for London (TfL) has success through strict adherence to four design principles: Efficiency, Usability, Understanding, Quality (Transport for London 2009).

Use multiple forms of outreach, in advance and sustained over time, for successful public education on transit: information kiosks, outreach in schools, trial periods, station ambassadors, door-to-door visits by transit cadres, local news segments.

Utilization of smartphone applications can provide better information on walking, bicycling, and public transit, making it easier and socially appealing to use those low-carbon modes of transport.

For motorized transport, outreach programs can target specific groups about fuel-efficient driving strategies: taxi drivers and hired drivers, truck drivers, bus drivers, and private vehicle drivers.

Monitoring Metrics

Metrics that relate specifically to this recommendation are:

- Shifts in transport mode share related to outreach campaigns and pilot projects
- Improvements in public transit ridership and speed
- User satisfaction (measured via survey)
- Number of participants in driver training programs
- Reduction in fuel consumption (before and after driver training)

Case Studies

Optibus Phase II, Public Outreach Campaign, Leon Bus Rapid Transit, Mexico

Sources: EMBARQ 2009; https://unfccc.int/secretariat/momentum_for_change/items/7153.php

Optibus was first launched in 2003, the first Mexican Bus Rapid Transit (BRT) system with feeder busses. Optibus is a central component of the transportation system, with the goal of greater efficiency, safety, and reliability, reduction of travel time and congestion and emissions, with improved accessibility for the urban poor and disabled. By 2008 the system was over capacity, and in 2010 a second phase was undertaken. To inform and engage the public about the extended BRT, city officials in Leon, Mexico, undertook multiple outreach campaigns. Information sessions were conducted with current bus riders. Theater performances and information sessions took places in schools. A cadre of employees went door-to-door to explain the BRT extension and answer questions. Demand is currently near 700,000 trips per day, on 30 km of dedicated bus lanes, with 65 stations and 4 main terminals, run with 92 articulated buses and 69 feeder routes. The strong public outreach and ridership enabled the replacement of 200 polluting buses, savings 2 million liters of fuel and 6,000 tonnes CO₂ per year.

Safe and Fuel Efficient Driving (SAFED) training program, UK

<http://uk-roadsafety.co.uk/safed.htm>

In the UK, the one-day Safe and Fuel Efficient Driving (SAFED) training program was initiated in 2003 with government funding and has since trained 12,000 heavy goods vehicle (HGV) truck drivers as well as 7500 van drivers. Pilot studies of the program has demonstrated fuel savings of around 10%, as well as reduced fuel costs, reduced emissions, and reduced insurance premiums. The UK SAFED driver training for van drivers has resulted in 16% fuel consumption reduction on the day of training and 5% reduction overall (SAFED 2008). The SAFED demonstration program for bus drivers is estimated to deliver potential fuel efficiency improvements of 8-12% (UK Dept of Transport 2010).

Attributes

- Carbon Savings Potential
Low

Though direct carbon savings from public outreach may be relatively low, public outreach is essential for enabling other low-carbon transportation policies.

- First Cost to Government
Low
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced fuel and/or electricity savings, improved air quality, improved public health

Tools and Guidance

Educational Resources by Department of Planning, Transport and Infrastructure, Government of South Australia

<http://www.transport.sa.gov.au/educational/>

DPTI provides services to different groups based on their different interests in order to influence the way people use the transport system, particularly with respect to safety and the environment.

California Department of Education Transportation Training

<http://www.cde.ca.gov/ls/tn/im/>

Instructional training materials for school bus, transit bus, and farm labor vehicle drivers and information about preparing and certifying instructors who teach this curriculum.

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UK Road Safety Ltd. 2011. "Eco-Driving." Online: http://www.uk-roadsafety.co.uk/ECO_Driving/ECO_Driving.htm

T14: Clean Vehicle Programs

Description

Clean vehicle programs are intended to encourage and accelerate low emission, zero and near zero emission, on road light-duty vehicle penetration and deployment. They can benefit a city by providing immediate air pollution emission reductions, as well as reducing greenhouse gas emissions, while stimulating development and deployment of the next generation of zero emission and plug-in hybrid electric vehicles. Subsidies can be offered to alternative vehicle or subsidies for replacing old inefficient vehicle. Accelerating the market for zero-emission vehicles (ZEVs) is a long-term transportation policy strategy to reduce localized pollution and greenhouse gas emissions, save consumers money, and enable sustainable economic development. In addition to promoting vehicle technologies, these programs support the development and use of low carbon fuels. As one example, in March 2012, Governor Brown issued an executive order directing state government to accelerate the market for ZEVs in California. Incentives are aimed at the buyer of the clean vehicle in the form of rebates and tax credits. The Chinese Ministry of Science and Technology has also launched a 1,000 clean energy vehicle program in ten cities.

Implementation Strategies and Challenges

Implementation Activity	Description
Monetary Incentives for Buyer	Cities can leverage state or national tax breaks for owners of clean vehicles, and provide additional rebates to buyers of clean vehicle.
Convenience and Privilege Incentives for Buyer	Provide clean fuel infrastructure for re-fueling routinely on main streets; make free parking available for clean vehicles; designate carpool lanes to avoid traffic or lines for clean fuel vehicles.
Fuel Producer and Distributer Incentives	Give highest priority incentives to clean electricity providers for vehicles. Carefully utilize tax credits for alternative clean fuel produced or blended, considering life-cycle energy impacts on ecosystems and food production.
Public Procurement	A buyers consortium can increase the market share of clean and electric vehicles. Government can lead by example with purchase of electric and clean fuel busses as well as other public vehicles.
Vehicle Manufacturing Incentives	Government subsidies for clean vehicle manufacturing can increase the supply and market. Cities can leverage or augment state and national government tax breaks for manufacturers. Government endorsement of clean vehicles can enhance the reputation of clean vehicle manufacturers..

Additional insight on implementing clean vehicle programs comes from California experience (CARB 2012).

First, align the stakeholders to develop an action plan. In California's case, the implementation action plan is led by the Governor's Office, and includes several state agencies and associated

entities and builds upon significant work already undertaken by these agencies. The action plan also benefits from extensive input from outside stakeholders, including the California Plug-in Electric Vehicle Collaborative (PEVC) and the California Fuel Cell Partnership (CaFCP). PEVC and CaFCP are broad-based public-private partnerships, with industry, non-government organizations and government members that collaborate to advance ZEVs.

Second, the program needs to have a clear scope of eligibility and time frame. In California's case, there are four different types of vehicles eligible for the program: zero emissions vehicles, plug-in hybrid electric vehicle, neighborhood electric vehicles, and zero emission motorcycles. In some cities, the replacement program only focuses on government-controlled fleets or on city public transportation such as taxi or buses.

Third, the program should have solid funding source and clear rule of subsidies. The city may combine the sources at federal, state or city level. It can also be transferred from other programs for example parking fee, toll fee or vehicle registration tax. In California, Federal Tax credits for ZEV and PHEV range from between \$2,500 to \$7,500, with factors such as battery capacity determining how much owners are eligible to receive. In Riverside, the city provides \$250 to \$2500 depending on the vehicle types.

Monitoring Metrics

Some suggested measures that relate specifically to this recommendation are as follows:

- New purchase of alternative vehicles
- Replacement of old inefficient vehicles
- Avoided energy and carbon emission by new purchase and replacement

Case Studies

Alternative Fuel Vehicle Rebate Program, Riverside, California

Source: <http://riversideca.gov/publicworks/air/alternativefuel.asp>

The program provides a rebate to City of Riverside residents who purchase or lease a qualified new alternative fuel or electric vehicle and meet the applicability requirements. All vehicles must have the original manufacturer's alternative fuel equipment (vehicles with conversions will not qualify). Rebates for several types of clean vehicles are included in this program. New Electric Vehicle Rebate: \$2,500 rebate for the purchase or lease of a new qualified electric vehicle. Electric vehicles include those powered exclusively by batteries or hybrid technologies, which allow the vehicle to be plugged in for recharge. New Electric Motorcycle Rebate: \$500 rebate for the purchase or lease of a new qualified Electric Motorcycle. New CNG Vehicle Rebate: \$1,500 rebate for the purchase or lease of a new qualified Compressed Natural Gas (CNG) vehicle. New Neighborhood Electric Vehicle Rebate: \$250 rebate for the purchase or lease of a new qualified Neighborhood Electric Vehicle.

Stockholm Clean Vehicle Incentives

http://www.biofuelcities.eu/fileadmin/template/projects/biofuels/files/Policy_Centre/The_Stockholm_Case.pdf

Stockholm has more clean vehicles on the road than any other country in the world. They have accomplished this through a blend of incentive programs. Some national policies provide tax breaks and make sure that there is a high availability of refueling stations for clean fuel vehicles. Local policies focus on making clean vehicles a convenient way to travel. One example is in Stockholm Arlanda Airport, where clean vehicles and taxis are allowed to be the first in line. Partnerships between local and national governments align clean vehicle policies and make programs more successful.

Attributes

- Carbon Savings Potential
Medium
Energy savings may reach 8,000-10,000 kWh/annual for each new high performance vehicle or replaced vehicle, with subsequent benefits in carbon reduction. Hybrid, all electric, or fuel cell vehicles have lower GHG emissions compared to fuel-based vehicles. The emission reduction potential depends on the size of the fleet and type of vehicles, with reported reduction of 50% in the UK Green Cars program when compared to traditional black cabs and 20% reduction from 1990 levels in San Francisco's bus program (UK Dept for Transport 2009; SFMTA 2011).
- First Cost to Government
Medium
Additional initial costs are on the order of US\$1000-2000 per vehicle or more. If clean vehicle programs are focused on city fleets, these costs are born by government; otherwise, businesses bear the costs of upgrading to cleaner vehicles. Fuel savings can recoup costs during operation; payback period varies depending on type of vehicle and amount of driving.
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced fuel and/or electricity savings, improved air quality, improved public health

Tools and Guidance

Clean Vehicle Rebate Project, Center for Sustainable Energy, California

<http://energycenter.org/index.php/incentive-programs/clean-vehicle-rebate-project>

The Clean Vehicle Rebate Project (CVRP) is funded by the California Environmental Protection Agency's Air Resources Board (ARB) and administered statewide by the California Center for

Sustainable Energy (CCSE). The site provides the background of high performance vehicle, overall design of the program and a step by step guidance to the program application.

Clean Vehicle Rebate Project Implementation Manual

http://energycenter.org/index.php/incentive-programs/self-generation-incentive-program/sgip-documents/doc_download/533-clean-vehicle-rebate-project-implementation-manual

References

California Air Resources Board (CARB). 2012. Facts about California Clean Vehicle Incentives. Online: http://www.arb.ca.gov/msprog/consumer_info/advanced_clean_cars/consumer_acc.htm

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Senternovem. 2009. The City of Stockholm. Case Study in *The Handbook For the Local Implementation of Clean(er) Fuel Policies in Europe*. Online: http://www.biofuel-cities.eu/fileadmin/template/projects/biofuels/files/Policy_Centre/Biofuel_Cities_Handbook.pdf

UK Department for Transport (DfT). 2009. Low Carbon Transport: A Greener Future. Online: <http://www.official-documents.gov.uk/document/cm76/7682/7682.pdf>

Water Policy Recommendations

- W01: Water Management Plan
- W02: Codes, Consumer Education, and Incentives for Water-Efficient Products
- W03: Prioritize Energy Efficient Water Resources
- W04: Improve Efficiency of Pumps and Motors
- W05: Active Leak Detection and Pressure Management Program
- W06: Methane Capture and Reuse/Conversion
- W07: Public Education Measures
- W08: Facility Operator Training Program

W01: Water Management Plan

Description

A comprehensive water management plan is an integral part of a successful water management program. Water management plan helps a municipality set achievable water conservation goals and identify water conservation opportunities. The plan should include clear information about how a municipality uses its water, from the time it is piped into the facility through disposal. Knowledge of current water consumption and its costs is essential for making the most appropriate water management decisions. A water management plan can be divided into three components: water accounting, best management practices (BMPs) achieved, and water management opportunities (U.S. EPA, 2012). It is important to include the following elements: (1) water use policy statement and goals which ties water efficiency into the long term objective; (2) water resource and water use information and projects such as water demand, water supply, water reliability, water quality, water use efficiency, water recycling and wastewater treatment and so on; (3) water metering or measurement plan which could track water use on an ongoing basis; (4) provide the necessary staff and financial resources available to track water use and implement water use conservation and wastewater treatment projects.

Implementation Strategies and Challenges

Implementation Activity	Description
Audit and Retrofit Treatment Facilities	An audit and retrofit program identifies all energy consuming components of the water treatment process and invests in high efficiency upgrades. It can be applied for the following plant installations: water treatment, sanitary sewage treatment, and sludge treatment. See case study on Columbine Water Treatment Plant.
Water Meter Program	Water metering empowers consumers to monitor their water use and control the amount of money they spend on water. By helping consumers realize that water is a costly resource that is not infinitely available, water metering and correct billing often lead to customers using less water, both within and outside the home. Importantly, metering is a useful tool to help water companies and residents delineate ownership and identify water leakage, enabling early leak detection. See case study for Soweto, South Africa.
Improve Performance of System Networks	The municipality can develop a program to identify the opportunity to improve the hydraulic performance of the following systems: extraction works and pipelines, long distance water transmission mains, distribution networks, sewage pumping mains, district cooling networks and irrigation networks. See case study for Moulton Niguel, U.S.
Formation of Ring Main	Network hydraulics can be optimized by completing or extending the network, though the creation of a continuous “ring main” that links up two

	conveniently located parts of the network which are strained on pressure. Hydraulic constraints and inefficiencies can be identified by investing in hydraulic modeling, flow/pressure tests, and/or Supervisor Control and Data Acquisition (SCADA). Creating a loop within the network may effectively shorten the distance water will have to flow and help to redistribute the flow more evenly and efficiently in both directions. Hence, the opportunity is created to reduce required pump delivery head and associated energy required at source will also be minimized. In addition, a ring main will improve network reliability and security by providing an alternative route so that provision will not rely on one route alone. Implementing this recommendation can therefore help to reduce leakage and the risk of bursts (as pressures will be lowered) and can reduce the need to replace main. See case study for London, UK.
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Possible challenges for implementing water management plan include: lack of financial and staff resources; lack of water monitoring system to track water resource and water use information and data; lack of designed incentives to implement water conservation and wastewater treatment measures and projects.

Monitoring Metrics

City authority implementing a water management plan should monitor some of the following quantities to ensure a successful outcome:

- Water saving rate of water conservation projects or measures
- Residential connections with an operating meter
- Water consumption per capita per day
- Length of sewer pipes retrofitted
- Total length of water distribution networks replaced
- Frequency of sewer main breaks and blockages per 1000 properties
- Frequency of unplanned interruptions per 1000 properties
- Percentage of properties that have experienced a planned water interruption
- Percentage of properties below minimum water pressure

Case Studies

Water Treatment Plant Retrofit, Columbine, U.S.

<http://www.waterworld.com/index/display/article-display/228624/articles/waterworld/volume-21/issue-5/awwa-feature-articles/uf-membrane-retrofit-nearly-doubles-treatment-plant-capacity.html>

Rather than build a new plant or expand an existing plant with conventional technology, water managers in Columbine, Colorado chose to retrofit their wastewater plants with immersed hollow-fiber

ultra-filtration (UF) membranes. As a result, they have doubled or even tripled plant output while significantly improving treated water quality. This can often be achieved with little or no expansion of the plant footprint. For the Columbine Water Treatment Plant (WTP), a large 30 million gallons per day (mgd) dual-media gravity filtration facility in the City of Thornton, CO, retrofitted their existing filter basins with advanced UF membranes in order to meet the fiscal, technical, and performance requirements for the 30-year-old facility. In October 2004, the Columbine WTP was shut down, and Garney Construction began work on retrofitting the filter basins with ZeeWeed UF membranes. During the retrofit, the city's second WTP, a 20 mgd facility, would provide enough water to fulfill the 11-12 mgd of demand throughout the winter months. The retrofit project was on an extremely tight schedule and work would have to proceed quickly in order for the plant to begin producing water in late March 2005, and be fully prepared to meet peak summer demand. In addition to the UF membrane retrofit, a new three million gallon clear well, a 60 mgd high service pump station, a chemical building, a maintenance building, and administrative offices were also constructed.

Rehabilitation of the Water Network and Private Plumbing Fixtures, Soweto, South Africa

<http://www.watergy.org/resources/publications/watergy.pdf>

Johannesburg Water (JW) initiated Operation Gcin'amanzi (Operation Save Water), in Soweto as a multi-faceted project focusing on the rehabilitation of the water network and private plumbing fixtures alongside water metering. Pre-pay metering ensures that everyone gets a basic allowance of water but those who use water excessively are billed accordingly. The project was launched after a lengthy consultative, awareness, and approval process with communities, councilors, ward committees, and trade unions. Operation Gcin'amanzi is estimated to cost ZAR 500 million (321 million RMB)⁶⁶ when completed. Although the project initially received negative publicity, based mostly on misinformation and opposing political ideologies, the project is now supported by 96% of participating residents. Once all phases are completed, JW will save almost ZAR 270 million Rand (173 million RMB) per year in bulk water purchases alone. The effective payback period of the project is less than three years. Note that this does not include savings from the associated reduced energy use of 175 million kWh per year.

Energy Efficiency Strategies, Moulton Niguel, USA

<http://www.energy.ca.gov/process/pubs/moulton.pdf>

In the early 1990s, facing a major rise in energy costs, Southern California's Moulton Niguel Water District explored other methods to increase energy efficiency. Working closely with Southern California Edison and San Diego Gas & Electric to identify optimal rate schedules and energy-efficiency strategies, the district implemented a program in 1992 that has yielded substantial savings in the reservoir-fed

⁶⁶ According to current exchange rate 1 ZAR = 0.642 CNY. Accessed on 05/23/2013 in <http://www.xe.com/currencyconverter/>.

branches of their distribution system. The District modulates wastewater flows by installing a proportional, integral and derivative/variable frequency drives system. Automated controls and programmable logic controllers are also used to enable 77 district pumping stations to benefit from lower off-peak utility rates when purchasing electricity for pumping water. It was also specified that all motors used in new construction should be 95-97% efficient. The District now saves nearly US\$320,000 (2.02 million RMB)⁶⁷ annually by using programmable logic controllers to control off-peak pumping. First-year savings for Moulton Niguel's Country Village station were over US \$69,000 (435,390 million RMB). In 1994, the District's electric bill fell more than 20%, from US \$1.5 million (9.5 million RMB) to US \$1.18 million (7.4 million RMB). These savings are particularly meaningful considering that Moulton Niguel has been impacted by a 14% electricity rate increase. The use of the proportional, integral, and derivative/variable-frequency drives system for wastewater pumping has reduced pumping energy costs by about 4%. In addition, San Diego Gas & Electric has paid cash rebates to the District for installing variable-frequency drives - over US \$30,000 (189,300 RMB) in 1993/1994. Electricity savings, combined with the utility rebates, offset the cost of installing the system.

Ring Main, Thames Water, London, UK

<http://www.thameswater.co.uk/cps/rde/xchg/corp/hs.xsl/2923.htm>

Thames Water will be extending the existing Ring Main to enable water transfer across a greater area of London. These works are part of plans for the future management of the Ring Main, providing increased security and flexibility. The tunnel designs allow for large quantities of water to be moved under gravity therefore avoiding energy intensive pumping and its associated greenhouse gas emissions. In the event of a major burst main or incident that would drastically affect customers supply, the work will enable the movement of bulk amounts of water to the affected areas, minimizing the impact of any loss of water supply. The project will increase ability to move water around the city but will not have any impact on the amount of water that is treated. The funding for the program was agreed with their regulator, Ofwat, and will be funded through the increases in customer bills for 2005 to 2010. Negative impacts of the construction work were mitigated through the selection of appropriate construction methods and working hours, and by gaining local knowledge through consultation with the relevant councils and other local groups.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
<1 year

⁶⁷ World Bank official exchange rate of 2012: 1 USD = 6.31 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>.

- Co-Benefits
Reduced carbon emissions; enhanced public health; increased employment opportunities;
financial savings; security of supply

Tools and Guidance

U.S. Department of Energy. Best management practice: water management planning. Available at: https://www1.eere.energy.gov/femp/program/waterefficiency_bmp1.html.

References

U.S. Environmental Protection Agency (U.S. EPA), 2012. Developing a water management plan. Accessed at December, 2012. Available at: <http://www.epa.gov/oaintmnt/water/plans.htm>.

W02: Codes, Consumer Education, and Incentives for Water-efficient Products

Description

Water efficient fixtures and fittings reduce not only water consumption but also the associated energy needed to treat and transport water. Efficient fixtures and fittings can also help to raise consumer's awareness of the link between water use and energy consumption and generally leads to the consumer installing additional energy efficient products. This recommendation will apply to potable water and irrigation networks. Specifically, it targets the development of an incentive program or mandate to increase the number of local rainwater collection tanks in buildings, increase the reuse of rainwater, and promote the installation and use of more efficient water fittings. Types of energy and water efficient fixtures applicable to both retrofits and new construction include: 1) low flow taps and showers, 2) water efficient white goods, 3) dual, very low, or siphon flush toilets, 4) low flush or waterless urinals, 5) bubble irrigation that involves less water being lost through evaporation, and 6) rainwater harvesting tanks.

Implementation Strategies and Challenges

Implementation Activity	Description
Feasibility Study	The City Authority (CA) can help to establish appropriate partnerships to undertake a feasibility study of incorporating water efficient fixtures and fittings. The CA should engage a team that includes network planners; water, energy, and utility engineers; environmental specialists; and financial advisors to ensure that the feasibility study captures all pertinent aspects. The feasibility study helps to establish the technological and financial viability of various procurement and policy options for water efficient fixtures. It defines water demand in the context of the efficiency of current provision methods (liters per flush, flow delivered, percentage of leakage in pipes, water usage per fixture). Technical ability, incentives and taxes should also be given consideration.
Direct expenditures & procurement	The CA pays for upgrades to the fixtures and fittings within government buildings directly out of the city budget or through separate funding mechanisms. The advantage of this strategy is that having the legislative authority to take ownership of the intervention will facilitate compliance with local legislation and policies. This option may not be appropriate if the CA does not own the buildings. Case Studies: Soweto, South Africa; Preston, UK.
Legislative Enforcement	The CA exercises its legislative power to set obligatory fitting efficiency thresholds that must be met. The CA can influence the design of new buildings by making incorporation of water saving devices mandatory. It is particularly desirable for the CA to lead by example by specifying inclusion of low flow fixtures and fittings in their briefs for design of

	new government buildings. NOTE: The ENERGY STAR standards for low-flow toilets and faucets are 1.28 gallons (4.8 liters) per flush and 1.5 gallons (5.7 liters) per minute, respectively. The International Plumbing Standard for showerheads is 2.5 gallons (9.5 liters) per minute. Case Study: Delhi, India
Partnering Programs for Residential Sector	The CA liaises with established organizations and/or coalitions (frequently non-profit) to gain access to their experience and expertise in order to evaluate and implement the most appropriate interventions for the situation. Such organizations often undertake research, educational programs, engage in policy advocacy, design and implement water and energy efficiency projects, promote technology development and deployment, and help to build public-private partnerships. Difficulty often arises where the partnering organizations do not have access or influence over the funds required to implement the initiatives. Case Study: Preston, UK
Subsidies	The CA establishes subsidies and allowances to incentivize customers to directly and actively engage in implementing more water efficient fittings. The CA will also have the choice of managing and/or promoting preferred subsidized schemes. This activity may be complemented by educating the public on the benefits of water efficient products. Case Studies: Preston, UK; Kirkless, UK; Albuquerque, USA.
Raise Awareness of Sustainable Products and Services	The CA invests in publicity and promotion of water efficient products and services to raise awareness of the products available and encourage the local community to engage with new water efficient technology. This activity may be complemented by offering subsidies or a rebate to those who are willing to invest in water efficient products. Case Studies: Preston, UK; Leicester, UK; Albuquerque, USA.

Possible challenges for implementing this measure include: lack of adequate financial and staff resources; lack of data monitoring and collecting system; lack of effective design of financial incentives.

Monitoring Metrics

The government body in charge of implementing a program (codes, education, incentives, or otherwise) on water efficient products should measure the following quantities prior to and during program implementation:

- Water consumption per capita per day
- Number and percentage of households claiming subsidies/rebates for purchasing water efficient technologies
- Number of low flow fixtures and fittings purchased

Case Studies

Rehabilitation of the Water Network and Private Plumbing Fixtures, Soweto, South Africa

<http://www.watergy.org/resources/publications/watergy.pdf>

Johannesburg Water (JW) initiated Operation Gcin'amanzi (Operation Save Water) in Soweto as a multi-faceted project focusing on the rehabilitation of the water network and installation of private plumbing fixtures with water metering. Once all phases are completed, JW will save almost ZAR 270 million (321 million RMB)⁶⁸ per year in bulk water purchases alone. The effective payback period of the project is less than 3 years. Note that this does not include savings from the associated reduced energy use of 175 million kWh per year.

Reducing Water Demand in Social Housing, Preston, UK

<http://www.waterwise.org.uk/images/site/Research/preston%20water%20efficiency%20initiative%20-%20interim%20report%20-%20october%202008%20-%20waterwise%20with%20partners.pdf>

The Preston Water Efficiency Initiative aimed to reduce water demand in social housing. The project was instigated in April 2007 following funding by the Government of the South East (GoSE). The Reigate and Banstead Councils were given the responsibility of project managing and handling all financial matters concerning the project. The project involved a number of partners such as housing and environment organizations, such as the Raven Housing Trust.

A package of water efficient devices was offered to each household. The Raven Housing Trust visited each household to discuss the suitability of each device to the household and which devices would be fitted. Some of the devices were acceptable and practical to install to that particular household whereas others were not. The visit by Raven was followed up by a plumber visit to fit the appropriate devices and to leave full instructions and a telephone contact number.

The package of measures encompassed several aspects of saving water in the household. Areas of saving included toilets, taps, garden watering, leakage, and clothes washing. These are the main areas where water is used around the home and in some cases where that usage is continuously increasing. Water savings from refurbishment (e.g. first time installation of showers rather than baths) were around 24% whereas the water savings from retrofitting (e.g. installation of lower flush toilets) were around 15%.

⁶⁸ According to current exchange rate 1 ZAR = 0.642 CNY. Accessed on 05/23/2013 in <http://www.xe.com/currencyconverter/>.

Energy and Water Conservation Fund, Kirklees Metropolitan Council, UK

<http://www.managenergy.net/products/R319.htm>

In 1992, Kirklees Metropolitan Council (KMC) adopted the Friends of the Earth environmental charter for local government, which aimed to reduce carbon dioxide emissions from KMC operations by 30% by 2005, from a 1990 baseline. The Energy and Water Conservation Fund was set up to enable KMC services to make capital investments in energy efficiency in buildings and to help attract external funding for energy projects. For most projects, the fund gave loans rather than outright grants, which were repaid out of savings made from lower energy and water bills.

Around 10% of the fund (approximately 631,000 RMB) was spent on water (push taps, urinal flush controls, shower controls, rainwater recovery systems, waterless urinal controls, and a mat watering system at Bradley Central Plant Nursery). Over the three-year period, energy savings of 6% were achieved. At the same time, water management measures produced savings of around US\$190,000 (1.2 million RMB)⁶⁹.

Rainwater Harvesting, Delhi, India

Measures for Ensuring Sustainability of Rainwater Harvesting, Water for Asian Cities Program Rain Water Harvesting and Artificial Recharge to ground water: A Guide to follow. 2008.

Rapid urbanization and population growth have caused acute water shortages and a drastic drop in the groundwater table in Delhi, India. A number of measures are being promoted to address the falling groundwater levels. One of these measures involves a Ministry of Water Resources program for rainwater harvesting and recharge of the groundwater system.

The Municipal Corporation of Delhi has given instruction to make rainwater harvesting mandatory in all new buildings with a roof area of more than 100 square meters on plots exceeding 1,000 square meters. The potential of rooftop rainwater harvesting is approximately 125,000 liters for a plot size of 250 square meters based on an annual rainfall of 1,000 millimeters.

If the scheme is implemented throughout the city of Delhi the additional recharge to groundwater will be around 76,500 million liters per annum. If the water level rise from this recharge is as expected, this will amount to a savings on energy used for pumping of US\$16,000 (111,200 RMB)⁷⁰ per day. Over and above this saving on conventional water supply, there will be a very significant energy saving. In floodplains, the energy saved for a 1 meter rise in ground water levels is around 0.40 kWh per cubic meter due to the reduced pumping needs.

⁶⁹ World Bank official exchange rate of 2012: 1 USD = 6.31 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>.

⁷⁰ World Bank official exchange rate of 2008: 1 USD = 6.95 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>.

Rebates for water efficient products, Albuquerque, USA

<http://www.cabq.gov/albuquerquegreen/green-goals/water>

The City Government of Albuquerque, NM and local companies are leading the way in developing and utilizing water efficient technology in their buildings. Toilets can account for more than 30 percent of indoor residential water use. The city of Albuquerque encourages its residents to install a high-efficiency toilet, which uses 1.28 gallons per flush or less. Rebates of US\$200 (1,390 RMB)³ per toilet are available when switching out old high flow toilets and these rebates apply to both residential and commercial customers alike. Rebates of US\$50 (348 RMB) are available for conversions from low-flow (1.6 gallon per flush) toilets to high efficiency toilets. Albuquerque issued roughly 27,500 toilet rebates to customers from 1995 to 2002 for a total rebate cost of US\$2,056,835 (14.3 million RMB). An additional estimated US\$252,175 (1.75 million RMB) was spent on staff time to administer ABCWUS's toilet rebate program from 1995 to 2002, for a grand total of US\$2,309,010 (16 million RMB) spent on rebates and staff time for the toilet rebate program during this period. All 27,500 toilet rebates yielded a total water savings of over 371 million gallons during the first year following the installation of the low-flow toilet. This is an annual savings from each toilet of approximately 13,475 gallons (Western Resource Advocates, 2008).

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
<1 year
- Co-Benefits
Reduced carbon emissions, efficient water use, improved air quality, enhanced public health, increased employment opportunities, financial savings, security of supply

Tools and Guidance

Water calculator: Questions relating to your home-lifestyle to estimate how much water and energy your household uses. Available at: <http://www.energysavingtrust.org.uk/watercalculator/flashcalculator>

Shower calculator: The calculator shows your potential water, energy and money savings if you spent one minute less in the shower. Available at: <http://www.eswater.co.uk/Showerenergycalculator.aspx>

Water use efficiency: This online calculator uses the Government's methodology for assessing the whole house water efficiency of new dwellings to assess compliance against the water performance targets in

Building Regulations Part G and the Code for Sustainable Homes. Available at:

<http://www.wrcplc.co.uk/PartGCalculator/Calculator.aspx>

Energy saving calculator: Ways to start saving energy in the home grouped by initial cost and potential annual costsaving. Available at: http://www.uk-energy-saving.com/energy_saving_calculator.html

Benchmark Water Use: The tool allows you to compare your site's water consumption with your industry's average. Available at: <http://envirowise.wrap.org.uk/uk/Topics-and-Issues/Water/Water-Tools/Water-account-tool/Benchmark-your-water-use.html>

Best Practice Reports: Waterwise East produced the best practice guide to support developers, housing associations, self-builders and others to deliver water-efficient new developments. Available at: http://www.waterwise.org.uk/reducing_water_wastage_in_the_uk/research/publications.html

Reference

Western Resource Advocates, 2008. *Smart savings water conservation: measures that make cents*.
[http://www.westernresourceadvocates.org/media/pdf/Smart%20Savings%20Water%20Conservation.p](http://www.westernresourceadvocates.org/media/pdf/Smart%20Savings%20Water%20Conservation.pdf)
df.

W03: Prioritize Energy Efficient Water Resources

Description

By investigating and identifying more appropriate and conveniently located water resources, opportunities to reduce treatment and pumping energy requirements can be maximized. This can also substantially reduce associated scheme construction costs by reducing the length of pipework required, pumping head, and the level of treatment needed. This can be done by a combination of alternative sources, increased use of gravity flow, rehabilitation of boreholes to improve flow, and rainwater capture. It is noted that care must be taken to ensure that exploiting the new water resources does not have significant environmental or social impacts.

Implementation Strategies and Challenges

Implementation Activity	Description
Feasibility Study	The City Authority (CA) can help to establish appropriate partnerships to undertake a feasibility study. The CA should engage a team that includes network planners, water and utility engineers, environmental specialists, and financial advisors to ensure the feasibility study includes all relevant aspects. The feasibility study should define the suitability of each water source according to location, elevation, quality, and quantity it could provide. Technical feasibility and procurement methodology should also be given consideration. Each option should be appraised against the specific requirements and capabilities of the CA.
Direct expenditures & procurement	Where the network is owned or run by the CA, the CA pays for changes to water resources directly out of the city budget or through separate funding mechanisms. The advantage of this strategy is that having the legislative authority to take ownership of the intervention will facilitate compliance with local legislation, policies, and planning permissions.
Legislative Enforcement	The CA exercises its legislative power to prioritize use of energy efficient water resources. The CA can also set appropriate water quality controls and mandatory energy use thresholds for the water system.
Partnering Programs	The CA liaises with established organizations and/or coalitions (frequently non-profit such as Alliance to Save Energy) to gain access to their experience and expertise in order to implement the most appropriate changes to the water resource infrastructure. Such organizations often undertake research, educational programs, engage in policy advocacy, design and implement water and energy efficiency projects,

	promote technology development and deployment, and help to build public-private partnerships. Difficulty often arises where the partnering organizations do not have access or influence over the funds required to implement the initiatives.
Water Company Collaboration	The CA incentivizes water authorities to develop a partnering program that will create more energy efficient water sourcing and distribution systems across the city. If the organizations and water authorities have no interest in the strategy, the CA may opt to subsidize the initial expense of any plant or hardware required and support the initiative through associated regulations.
Raise Awareness of Rainwater Harvesting	The CA invests in publicity and promotion of ways to capture and reuse rainwater. This helps to raise awareness of the products available and encourage the local community to engage with new water efficient technology, such as rainwater harvesting tanks. This activity may be complemented by offering subsidies or a rebate to those who are willing to invest in water saving products.

Possible challenges for implementing this measure include lack of awareness, and financial and technical resources.

Monitoring Metrics

The government or utility body in charge of water resources should measure the following quantities to ensure some level of water and energy savings:

- Percentage of water sourced from various methods (surface water, groundwater, desalination, or recycling) with associated pumping energy used per volume.
- Number and percentage of households claiming subsidies/rebates for purchasing and installing rainwater harvesting tanks

Case Studies

Gravity-fed Schemes, Moyamba Township, Sierra Leone

<http://sieragrassrootagency.tripod.com/id20.html>

Since the end of the war in 2002, the Moyamba District Council with the support of the World Bank has attempted to rehabilitate the old pumping station and the network of water supply lines in the Moyamba township. However, the high cost of pumping water has meant that water supplied through

this improvement cannot be sustained. The Ministry of Energy and Power has introduced a gravity-fed scheme for areas with gravity water (free water)⁷¹ sources. The money saved can be partly invested into supporting the pumping system during the height of the dry season when the water flow is low. The capital costs of gravity schemes are, on average, higher than the costs of schemes which obtain water from underground sources. This is due mainly to the cost of long pipelines from the upland sources down to the villages and partly to the cost of providing storage tanks. Operating costs, however, are usually lower for gravity schemes than for their underground counterparts. The project has been implemented by the Kaiyamba Chiefdom Development Committee with the cooperation and support of the Moyamba District Council and the full participation of the staff of the Water Works Department in Moyamba. SIGA, the NGO, represents the donors at the committee and is responsible for the coordination, disbursement, and procurement of all project activities. SIGA is also responsible for arranging and assisting with evaluation, monitoring, and reporting of the gravity-fed scheme.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
1-3 years
- Co-Benefits
Reduced carbon emissions, efficient water use, enhanced public health, increased employment opportunities, financial savings, security of supply

Tools and Guidance

Natural Resources Defense Council (NRDC), 2009. Water efficiency saves energy: reducing global warming pollution through water use strategies. Available at:

<http://www.nrdc.org/water/files/energywater.pdf>.

⁷¹ Water which moves into, through, or out of the soil or rock mass under the influence of gravity.

W04: Improve Efficiency of Pumps and Motors

Description

By adjusting, upgrading, or replacing the main components of pumps and motors, considerable energy savings can be realized system operations at the city or facility level. Additionally, a more appropriately rated pump will be subject to less wear and tear, which in turn reduces maintenance costs and the potential risk of damage to the associated pipeline and fittings. Off-peak pumping (for example refilling reservoirs overnight rather than during peak demand) assists power companies to achieve energy efficiencies at their main plant by leveling out the daily demand profile and enabling preferential tariffs to be offered to the end user. To maintain optimal energy performance over the long term, an appropriate operation and maintenance Program should also be developed and implemented on pumps and motors. The appropriateness of motor and pump replacements or upgrades will depend on the associated costs relative to the condition and remaining design life of the installed component. Each appraisal and development of implementation options must be conducted separately for each specific network.

It may be possible to replace and/or improve the operating efficiency of pumps and motors associated with the following networks:

- Extraction works and pipelines
- Long distance water transmission mains
- Distribution networks
- Sewage pumping mains
- District cooling networks
- Irrigation networks

Implementation Strategies and Challenges

Implementation Activity	Description
Feasibility Study	The City Authority (CA) can help to establish appropriate partnerships to undertake a feasibility study. The CA should engage a team that includes network planners, water and utility engineers, environmental specialists, and financial advisors to ensure the feasibility study captures all pertinent aspects. The feasibility study should establish the baseline city energy expenditure associated with water supply/waste water treatment and the efficiency of pumping and motors across the network(s). Technical feasibility and procurement methodology should also be given consideration. Each option should be appraised against the specific requirements and capabilities of the CA.
Direct expenditures & procurement	Where the water network is owned or run by the CA, the

	CA pays for the audit and upgrades of the pumping/motor infrastructure, directly out of the city budget or through separate funding mechanisms. The advantage of this strategy is that having the legislative authority to take ownership of the intervention will facilitate compliance with local legislation and policies. This activity may not be appropriate if the CA does not own the utility infrastructure.
Energy Services Company	The CA enlists an ESCO to undertake the audit and replacement project. There are multiple tactics for engaging an ESCO, including part- and full- ownership of the system. It is recommended that if the ESCO approach is pursued, the CA first explores numerous implementation options and assess the pros and cons of each.
Efficiency Standards	The CA regulates that the water companies under its jurisdiction use pumps and motors of a minimum standards of energy efficiency.

Possible implementation challenges for this measure include: lack of effective design of incentives for water companies, facilities and consumers to improve their motors and pumps; lack of data monitoring and collecting system to track the energy efficiency of motors and pumps.

Monitoring Metrics

The government or utility body in charge of water resources should measure the following quantities to ensure some level of energy savings from the pump and motor program:

- Energy used per liter of potable water supplied (kWh/liter)
- Percentage of energy saved (energy savings in comparison to historical energy consumption figure for a given pumping station)

Case Studies

No- and low-cost Energy Efficiency Measures, Pune, India

<http://www.watergy.org/resources/publications/watergy.pdf>

The Pune Municipal Corporation (PMC) partnered with the Alliance to Save Energy to help them to implement no- and low-cost efficiency measures across municipal water utilities. Energy audits were conducted on PMC's bulk water supply systems and hands-on training was held for PMC engineers. PMC also contributed a total of US\$189,000 (1.19 million RMB)⁷² to implement a series of capital intensive efficiency measures. Municipal water utilities in India spend upwards of 60% of their budget on energy

⁷² World Bank official exchange rate of 2012: 1 USD = 6.31 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>.

for water pumping. As a result of energy efficiency measures, PMC experienced annual energy savings of 3.78 million kWh and annual cost savings of over US\$336,000 (2.12 million RMB). The savings achieved at PMC are higher than projected in the energy audit report since the PMC municipal engineers implemented additional low- and no- cost energy efficiency measures at the pumping stations including distribution pumping stations. This is a direct result of the training provided to the municipal engineers by the Alliance to Save Energy. The implementation of energy efficiency measures such as improving energy efficiency for water pumping also resulted in 10% additional delivery of water to community without adding any new capacity. In addition to direct reductions in energy costs, the utility also saved money by qualifying for a rebate program offered by the Maharashtra State Electricity Board to facilities maintaining a good power factor and reducing usage during peak hours. The efficient operation of the largest pumping station, Parvati Water Works, reduced its energy intensity of water supply by 6% (from 375 to 352 kWh/million liters of water), and increased its rebate by almost 8% since fiscal from US \$110,000 (694,100 RMB) to US \$196,000 (1.24 million RMB).

Improving the Distribution of Water, Fortaleza, Brazil

<http://www.watergy.org/resources/publications/watergy.pdf>

The Alliance to Save Energy worked alongside the Companhia de Agua e Esgoto do Ceara (CAGECE) in the Northeast of Brazil to develop and implement measures to improve the distribution of water and the access to sanitation services. The water systems needed to expand to satisfy increasing demand without sacrificing efficient use of energy. The project improved system management by centralizing control. It also developed financing proposals with the Government of Brazil Fight against Electricity Waste Program (PROCEL) in order to implement energy efficiency projects with CAGECE's operations crew. These projects included automation of operations, rewinding and replacing motors, maximizing existing pump systems efficiency, and increasing storage capacity to allow pumps to be shut down during peak electricity rate hours. Over the course of four years, CAGECE saved 88 GWh of energy, improving efficiency each year. Before CAGECE instituted their energy efficiency program, they provided access to 442,400 households. Four years later, the utility was able to provide 88,000 new connections over the original baseline, while decreasing total energy consumption and maintaining water supply levels. Four years of official data show savings of over US \$2.5 million (15.78 million RMB) with an initial investment by CAGECE of only US \$1.1 million (6.94 million RMB). Another benefit was to introduce CAGECE to the tools and know-how to produce on their own initiatives that save energy and clean water. As a result, CAGECE achieved a 127% return on investment after four years.

Economical Pumping Solutions, Lichtenau, Germany

<http://www.lowara.co.uk/pressroom/casestories.php/24770>

Lichtenau is a small municipality with 3,600 inhabitants. Advice on water supply solutions was provided by a sales and service partner of the water pump company, ITT Lowara. This partner used the knowledge and support of Lowara to propose more economical and innovative pumping solutions. These sorts of collaborations ensure that even the smallest water boards can achieve considerable savings through improving efficiency of water supply systems. By replacing an old pump with a variable speed version they have reduced energy consumption by around 40%. The frequency converter on the pump ensures that the flow rate can be easily adapted to that of the other pumps in the system. The pump installed has been running perfectly for more than two years in Lichtenau, and a recent audit has shown that the pump consumes only 13.39 kWh, providing a saving of 8.34 kWh against the old cast iron pump, equating to a savings of 39%. During its service of some 5,827 hours to date, it has reduced consumption by 48,597 kWh. Based on a current energy cost of EUR 0.18/kWh (1.42 RMB/kWh)⁷³, the savings would be EUR 8,748 (69,197 RMB).

Energy Management Program, Madera Valley, USA

<http://www.energy.ca.gov/process/pubs/madera.pdf>

Madera Valley launched an energy management program in 1991 that enabled it to meet higher demand in 1994 without increasing operating costs. The program focused on modifying two wells to better maintain system pressure. At two other wells, Madera Valley has since upgraded its standard-efficiency motors to energy-efficient units. The combined improvements to Madera Valley's pumping operations enabled the agency to provide 22% increased capacity in 1994—from 514 million gallons in 1993 to 627 million gallons in 1994. In addition, energy costs per household fell by 22%—from an average US \$7.46 (47.1 RMB) per household each month in 1993 to an average US \$5.82 (36.7 RMB) in 1994. System-wide, this translated into annual savings of about US \$18,946 (119,549 RMB), or over 15% of total energy costs.

Water Treatment Plant, San Juan, Puerto Rico

<http://www.energy.ca.gov/process/pubs/sanjuan.pdf>

The San Juan Water District's Sidney N. Peterson Water Treatment Plant was built to be energy efficient and is operated to encourage energy and water conservation among customers and staff alike. The district even created an incentive program for its employees that rewards them with a percentage of the first year's savings from new cost-cutting techniques that they identify. A state-of-the-art facility, the Peterson plant uses gravity flow to minimize pumping needs for a 120 million gallon per day modular

⁷³ According to European Central Bank's official exchange rate from 23 May 2012 to 23 May 2013: 1 EUR = 7.91 RMB. <http://www.ecb.europa.eu/stats/exchange/eurofxref/html/eurofxref-graph-cny.en.html>

filtration system. Initial plant designs specified 15 horsepower backwash motors instead of 100 horsepower units, which reduced construction costs by 33% and lowered filtration energy requirements by 75%. A supervisory control and data acquisition (SCADA) system optimizes day-to-day performance and energy efficiency. To save more energy and money, district staff replaced standard-efficiency motors with energy-efficient motors to save US \$5,000 (31,550 RMB) per year. They also installed variable-frequency drives on flocculation and chemical feed pump motors to save US \$11,000 (69,410 RMB) per year. Finally, they launched water conservation education, promotion, and enforcement programs. Avoided pumping due to water conservation measures saves around US \$50,000 (315,500 RMB) per year.

USAID funded Ecolinks Project, Galati, Romania

<http://www.munee.org/node/62>

As part of a USAID funded Ecolinks Project, the Cadmus Group assessed the city's water supply system and discovered that a series of energy conservation measures could save roughly US \$250,000 (1.58 million RMB) per year in electricity costs. Low cost measures included trimming impellers to better match pumps and motors with required flows and pressures. Moderate cost measures included leak detection and reduction and limited pump replacement. A series of pumps replacements were recommended. For one pump's 5,854 hours of annual operation, it used roughly 2,500,000 kWh. A replacement pump and motor set could save roughly US \$55,000 (347,050 RMB) per year. For another pump with 6,000 hours of annual operation and consuming 3,000,000 kWh per year, a replacement pump and motor set could save roughly US \$42,000 (265,020 RMB) per year. Cadmus also estimated that reducing the height of the discharge would decrease the static head between the wet well in a low voltage pump station and the actual discharge. If the height of the reservoir was an average of 1 meter below the discharge and the discharge was lowered, roughly 10% of the pumping costs could be eliminated, saving roughly 100,000 kWh per year or US \$5,000 (31,550 RMB) per year.

Attributes

- Carbon Savings Potential
Medium
- First Costs to Government
Medium
- Speed of Implementation
1-3 years
- Co-Benefits
- Reduced carbon emissions, efficient water use, enhanced public health, increased employment opportunities, financial savings, security of supply

Tools and Guidance

Kitakyushu Initiative: A report focusing on building the capacity of the local governments to overcome the urban environmental and water problems. Available at:

http://kitakyushu.iges.or.jp/docs/sp/water/4%20Overview_Analysis.pdf.

Pump Efficiency Calculator: An online calculator tool to work out exactly how much could be saved by replacing a fixed speed damped or throttled centrifugal load with a variable speed drive controlled solution. Available at:

<http://www.abb.co.uk/cawp/seitp202/c253ae5e6abf5817c1256feb0053baf7.aspx>.

ESMAP Public Procurement of Energy Efficiency Services - Guide of good procurement practice from around the world. Available at:

http://www.esmap.org/Public_Procurement_of_Energy_Efficiency_Services.pdf.

W05: Active Leak Detection and Pressure Management Program

Description

In sewerage systems, identification and elimination of leaks can significantly reduce risk of ground contamination and lead to a more sustainable use of water resources. Pressure management can cost-effectively reduce treatment and pumping costs by minimizing the required delivery pressure and leakage. It is particularly suited to pumped mains and may require estimates of how demand changes over the day. Appropriately rated pressure reducing valves will in turn reduce the flow through leaks and the total flow that must be delivered by the pump upstream at the source/treatment works. This solution may be particularly appropriate in gravity flow networks. The key advantage of pressure management over leak detection is the immediate effectiveness. It is most appropriate where the network is expansive and features multiple small leaks that would be difficult and expensive to locate and repair.

A leak detection and pressure management program to minimize losses can be developed in the following systems:

- Extraction works and pipelines
- Long distance water transmission mains
- Distribution networks
- Sewage pumping mains
- District cooling networks
- Irrigation networks

It is anticipated that most systems would already be subject to passive leak detection, i.e. identifying leaks through visual observation, but that provides limited information and benefits. This recommendation therefore focuses on an active approach and more thorough leak detection program to locate and repair leaks. The following techniques could be used:

- Ground microphones
- Digital leak noise correlator
- Acoustic logger
- Demand management valves, meters, and zoning
- Mobile leak detection programs
- Basic acoustic sounding techniques

In addition excess pressure can be reduced by installing flow modulating valves on gravity networks or pump controls and/or pressure sensors to modulate a pump's relative performance to suit the daily variation in flow demand, thus maintaining maximum efficiency and minimum energy use.

Implementation Strategies and Challenges

Implementation Activity	Description
Feasibility Study	The City Authority (CA) can help to establish appropriate partnerships to undertake a feasibility study. The CA should engage a team that includes network planners, water and utility engineers, environmental specialists, and financial advisors to ensure the feasibility study captures all pertinent aspects. The feasibility study should establish the baseline city energy expenditure associated with water leakage, monitoring flow and demand to refine value and pump controls accordingly. Technical feasibility and procurement methodology should also be given consideration. Each option should be appraised against the specific requirements and capabilities of the CA.
Direct expenditures & procurement	Where the potable or wastewater network is owned or run by the CA, the CA pays for upgrades to the utility infrastructure, directly out of the city budget or through separate funding mechanisms. The advantage of this strategy is that having the legislative authority to take ownership of the intervention will facilitate compliance with local legislation, policies and obtaining planning permission. The main expenditure associated with pressure management will be mainly the acquisition and installation costs of the equipment (i.e. valve, control fittings).
Build-Own-Operate-Transfer (BOOT)	If the CA lacks ability to access capital and technical expertise, a Build-Own- Operate-Transfer (BOOT) type contracting mechanism may be deemed most suitable to implement this initiative. A Request For Proposals (RFP) can be released to attract bidders to implement efficiency measures and provide funding for the project, with remuneration paid through the resulting savings. This 'shared savings approach' is common in the electricity industry. The contractor is required to provide a basket of services including financing of capital, design, implementation, commissioning, operation and maintenance over the contract period as well as training of municipal staff in operations prior to handover. This sort of arrangement can be complex to set up and it can also be difficult to find an organization willing to take on the risk associated with this form of partnership.
Efficiency Standards	The CA regulates the Water Companies to meet leak

	reduction targets and ensure their pipes meet required standards of operational efficiency.
Community led implementation	The CA liaises with the local community to increase understanding of the benefits of leak detection initiatives. Simpler, less technical methods of leak detection and reporting provide a considerable opportunity for community involvement and participation. This activity may be complemented by offering subsidies to those who take part or by passing on the associated monetary savings to the community through reduced water rates.
Partnering Programs	The CA liaises with established organizations and/or coalitions (frequently non-profit such as Alliance to Save Energy) to gain access to their experience and expertise in order to implement the most appropriate changes to the pump and pipe infrastructure. Such organizations often undertake research, educational programs, engage in policy advocacy, design and implement water and energy efficiency projects, promote technology development and deployment, and help to build public-private partnerships. Difficulty often arises where the partnering organizations do not have access or influence over the funds required to implement the initiatives.

Possible challenges for implementing active leak detection and pressure management program include: lack of financial incentives and technical assistance; lack of awareness and in-depth understanding on the cost-effectiveness of taking this measure; lack of data and information on the current status of water supply networks.

Monitoring Metrics

The government or utility body in charge of water resources should measure the following quantities to ensure some level of energy savings from leak detection and pressure management program:

- Percentage of water unaccounted for (compares the volume used at users' meters with the total volume of treated water produced)
- Percentage of volume of water leakage per kilometer of water main per day
- Length and percentage of total water mains inspected for leakages
- Percentage of properties affected by low water pressure

Case Studies

Pilot Leak Detection and Abatement Program, Iasi, Romania

<http://www.resourcesaver.com/ewebeditpro/items/O50F1144.pdf>

With an EcoLinks Challenge Grant, Regia Autonoma Judeteană Apa-Canal Iasi (RAJAC) partnered with a U.S. environmental technology provider, Cavanaugh & Associates, to develop a pilot water leak detection and abatement program. The program trained RAJAC personnel in leak detection, implemented a leak detection system, and developed a water conservation program and public outreach campaign. This pilot leak detection and abatement study was a prerequisite for the implementation of a US\$40 million (252.4 million RMB)⁷⁴ infrastructure program. Awareness of new technology was significantly increased through training and seminars. The company's public awareness-raising program encouraged and enhanced consumers' capacity to participate in water conservation efforts. Environmental and economic benefits were derived from the more efficient use of water and energy resources. In the short-term, it was estimated that three of the leaks identified in the pilot scheme were responsible for a water loss of 60,000 cubic meters per year and a revenue loss of US \$24,000 (151,440 RMB). Since the equipment used during the pilot project cost approximately US \$20,000 (126,200 RMB) and no further significant investments were needed to eliminate the leaks, the payback period for the equipment was less than one year. This project contributes to a larger effort to improve water efficiency throughout Iasi County that will ultimately reduce water loss by 8 million cubic meters and provide a savings of US \$3 million (18.9 million RMB) per year, however, this level of savings, would require significant investment in the infrastructure.

Pressure Management, Emfuleni, South Africa

<http://www.watergy.org/resources/publications/watergy.pdf>

The Sebokeng/Evaton pressure management project use a Build-Own- Operate-Transfer (BOOT) type contracting mechanism because the municipality had only limited access to capital and lacked the technical capacity to implement the project. The savings in water were so significant that both the municipality and contractor profited highly, with 80% of the savings accrued to the municipality and the remaining 20% used as remuneration to the contractor for services provided over a five year period. As the installed infrastructure is permanent in nature and has a design life of at least 20 years, the municipality will continue to achieve savings well beyond the initial five year period. The staff also benefit from access to additional expertise and training. This project reduced water losses by over 30%, saving about 8 million liters per year with an equivalent financial value of around US \$3.5 million (22.1 million RMB). These water savings also translate into energy savings of around 14,250,000 kWh per annum due to the reduction in energy required to pump water. The project clearly demonstrated that the intervention of a suitable technology with a shared savings arrangement could succeed in low-

⁷⁴ World Bank official exchange rate of 2012: 1 USD = 6.31 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>.

income communities. Additionally, a private firm providing financing for technical innovation at no cost to the municipality received remuneration from sharing the resulting savings in water purchases.

Water Pressure Management Program, Sydney, Australia

<http://www.sydneywater.com.au/OurSystemsAndOperations/WaterPressureManagement/index.cfm>

Sydney Water has a water pressure management program to target those areas where pressure levels are well above average and there is a history of water main breaks. Excessive water pressure can lead to water main breaks and cause leaks in the city's water system. Water pressure management aims to adjust water pressure levels in the supply system to achieve more consistent pressure levels which will reduce the number of water main breaks, improve the reliability of the water supply system, and conserve water. The Water Pressure Management program is an important part of Sydney Water's leak prevention program and the New South Wales Government's Metropolitan Water Plan.

Water Supply and Drainage Project, Phnom Penh, Cambodia

<http://www.adb.org/water/actions/CAM/PPWSA.asp>

<http://www.adb.org/water/actions/CAM/Internal-Reforms-Fuel-Performance.asp>

The Asian Development Bank's (ADB) Phnom Penh Water Supply and Drainage Project provided the opportunity for the Phnom Penh Water Supply Authority (PPWSA), the government-owned water supply utility, to partner with ADB and demonstrate its capacity for catalyzing water sector reforms. To phase out non-revenue water, i.e. consumers gaining access to water supplies for free, PPWSA started metering all water connections. It gradually equipped each network with a pressure and flow rate data transmitters that provide online data for analyzing big leaks in the system. They also set up a training center to respond to in-house training needs. PPWSA renewed old pipes using state-of-the-art materials and labor from PPWSA staff. PPWSA also institutionalized performance monitoring, using progress reports and performance indicators on a regular basis and annually subjecting its accounts and procedures to an independent audit. The project advocated the transfer of more managerial autonomy to PPWSA to enable it to use its own funds on maintenance and rehabilitation programs. The result of the project was that PPWSA became financially and operationally autonomous, achieved full cost recovery, and transformed into an outstanding public utility in the region.

Attributes

- Carbon Savings Potential
Low
- First Costs to Government

Low

- Speed of Implementation

1-3 years

- Co-Benefits

Reduced carbon emissions, efficient water use, enhanced public health, increased employment opportunities, financial savings, security of supply

Tools and Guidance

International Water Association (IWA). Leak detection practices and techniques: a practical approach.

Available at: <http://www.iwapublishing.com/pdf/ACF1B18.pdf>.

W06: Methane Capture and Reuse/Conversion

Description

Methane is produced when the organic material in municipal and industrial wastewater decomposes anaerobically. In 2010, estimated methane emissions from wastewater accounted for 9% of global methane emissions (Global Methane Initiative, 2011). Most developed countries rely on centralized aerobic wastewater treatment systems to manage their municipal wastewater. These systems generate large quantities of sludge that are often treated in anaerobic digesters, which produce biogas that can range from 60-70% methane and 30-45% carbon dioxide on a dry basis.

There are two types of methane projects. The first type captures and burns (flares) methane. Through combustion, methane gas is turned into less potent greenhouse gases, carbon dioxide and water. Examples of such projects include the capture and flaring of landfill gas and of coal mining gas. The second type of project captures methane and uses it to produce either hot water or electricity. Such projects include those that capture and purify methane in wastewater treatment plants or landfills and use it for electricity production or the production of another form of energy.

Implementation Strategies and Challenges

According to the 2011 U.S. EPA Combined Heat and Power Partnership (CHPP) report, 43% of U.S. wastewater treatment facilities treating greater than 1 million gallons per day (mgd) operate anaerobic digestion. Only 8% of these facilities generate electricity or thermal energy using biogas (Willis et al., 2012). Inadequate payback and lack of available capital remain the dominant barriers to recovering power through anaerobic digestion with combined heat and power production. Legislations on tax credits, subsidies, grants, and low-interest loans to assist in financing CHP projects would help the sector.

Other main barriers fall into the categories of regulatory policy factors and human decision-making factors. Public agencies' decision-making bureaucracy/configuration can hinder biogas use. A surprisingly high percentage of survey and focus group respondents from smaller capacity (5-10 million-gallon-per-day) (19-38 million-liter-per-day) facilities have creatively found means to justify biogas use projects, while the mid-sized plants (10-25 million-gallon-per-day) (38-95 million-liter-per-day) identified inadequate gas production as a barrier. Enhancement of gas production, through co-digestion with food waste for example, can help overcome this barrier (Willis et al., 2012).

Local governments can use a number of implementation approaches to enhance the recovery of biogas produced from wastewater treatment plants.

Implementation Activity	Description
Qualification Assessment	At the early stage it is important to determine which technology is appropriate for the methane recovery of the considered wastewater treatment plant. Diverse technical and economic factors need to be considered, such as electricity and thermal energy demand as well as

	fuel (biogas) availability and quality.
Feasibility Analysis	It includes identifying project goals and potential barriers and quantifying technical and economic opportunities. Further feasibility analysis includes optimizing system design, accounting for capacity, energy output, and operational requirements. It should also include cost and expected investment return.
Procurement	Local government selects a qualified developer or contractor to finance and construct the project and ensure compliance with siting and permitting requirements.
Operations and Maintenance	Local government can enter maintenance contracts with equipment manufacturers and energy service companies for regular maintenance and operations.
Sell excess energy	Local government can connect to grid to obtain electricity to supplement the power produced by methane recovery projects, and to sell excess electricity to a local utility or provider.

Monitoring Metrics

The government bodies overseeing the methane capture or reuse program or facility operator overseeing a specific methane capture or reuse project should measure and monitor the following quantities:

- The total amount of biogas
- Annual electricity and heat production from biogas
- Investment costs
- Annual fuel savings
- Reduced CO₂ emissions

Case Studies

City of Albert Lea Wastewater Treatment Facility, Minnesota

http://www.globalmethane.org/documents/events_steer_20090910_scoping.pdf

In the summer of 2003, the city of Albert Lea, Minnesota, installed a 120-kilowatt (kW) CHP system at its wastewater treatment facility. The CHP system integrates four 30-kW micro-turbines and utilizes the recovered heat (28 million British thermal units [MMBtu] per day) from the turbines to maintain proper operating temperature of the anaerobic digester and provide a portion of the facility's space heating requirements. With funding from the Minnesota Department of Commerce's Conservation Improvement Program and the local utility, the CHP system provides 120 kW of backup power to operate critical systems during a utility power outage. The CHP system also saves the facility 800,000 kilowatt-hours per year (kWh/year), or 25% of its energy use. The CHP system has a payback period of approximately four to six years. In addition to representing a successful partnership among municipal,

utility, and state entities, the project successfully integrates a CHP system utilizing a renewable fuel, generates energy and cost savings for the municipality, and results in reduced air emissions.

Columbia Boulevard Wastewater Treatment Plant, Portland, U.S.

<http://www.chpcenternw.org/NwChpDocs/ColumbiaBlvdWastewaterCaseStudyFinal.pdf>

The Columbia Boulevard Wastewater Treatment Plant (CBWTP) in Portland, Oregon is the largest water treatment facility in the state. Operated by the Bureau of Environmental Services (BES) of the City of Portland, the plant treats an average of 80-90 million gallons (303-341 million liters) per day of sewage. In 1998, a 200 kW fuel cell running on biogas from the wastewater was installed to provide continuous power for the facility and waste heat for the maintaining process heating requirements. In addition, a 120 kW CHP system was used to produce electricity and thermal energy in 2003. A primary motivation for the fuel cell and CHP system was to provide backup power for the facility after it experienced several extended power outages during the mid-1990s. The fuel cell provided about US\$60,000 (378,600 RMB)⁷⁵ per year in net operating savings, while the CHP was estimated to provide higher savings at US\$70,000-80,000 (441,700-504,800 RMB) per year. The facility was financed by tax credits as well as multiple national, state, and utility grants.

Psytalia Wastewater Treatment Plant, Athens, Greece

http://www.eydap.gr/index.asp?a_id=358

The Psytalia Wastewater Treatment Plant (WWTP) is the main wastewater treatment plant in the greater Athens area, receiving an average wastewater flow of approximately 730,000 cubic meters per day. The Psytalia WWTP capacity is equivalent to a population of 5.6 million people, making it one of the biggest WWTPs in Europe and worldwide. Biogas produced at Psytalia WWTP is a renewable source of energy, and it is being utilized as the fuel in two CHP plants with a total capacity of 11.4 MW. Additionally a 12.9 MW CHP plant using natural gas operates at Psytalia, supporting the operation of the sludge thermal drying unit. The CHP plant system provides a considerable part of the heat needs of Psytalia WWTP (for sludge digestion and drying) as well as its electric power needs, while surplus power is sold to the National Power Grid Manager.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low

⁷⁵ World Bank official exchange rate of 2012: 1 USD = 6.31 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>.

- Speed of Implementation
< 1 year
- Co-Benefits
Reduced carbon emissions, fuel savings, increased employment, enhanced public health

Tools and Guidance

U.S. Environmental Protection Agency. Wastewater technology. Available at:
<http://water.epa.gov/scitech/wastetech/publications.cfm>.

References

Global Methane Initiative, 2011. Global methane emissions and mitigation opportunities. April, 2011. Available at: https://www.globalmethane.org/documents/analysis_fs_en.pdf.

Willis, J., Stone, L., Durden, K., Beecher, N., Hemenway, C. and Greenwood, R., 2012. Barriers to biogas use for renewable energy. Water Environment Research Foundation. London, United Kingdom. Available at: <http://www.nyserda.ny.gov/Publications/Research-and-Development-Technical-Reports/Environmental-Reports/-/media/Files/EERP/Commercial/Sector/Municipal%20Water%20and%20Wastewater%20Facilities/werf-biogas-barriers-report.ashx>.

W07: Public Education Measures

Description

Municipalities can develop programs to educate consumers on water conservation and recycling that reduce energy costs for both treatment and supply. This public education program could include promotional leaflets sent with monthly bills, advertisements, information on water company websites, and other outreach methods. A deeper understanding of the implications of water wastage, both in terms of energy used for treatment and supply as well as resource availability in the long term, will encourage consumers to use less water. This will also benefit the consumers as it will give them heightened awareness of water saving measures and the fiscal and environmental reasons for saving water. This improved awareness is something that they are likely to transfer to other consumers and businesses.

Implementation Strategies and Challenges

Implementation Activity	Description
Educational Workshops	The City Authority (CA) provides educational material and training to the water authorities and the organizations bearing the costs of water supply and treatment to help them provide water saving educational workshops to the public.
Exhibition of Sustainability	The CA can champion and promote sustainable water and energy use through their website or by sponsoring awards. By providing and showcasing practical experience on how energy and water is saved, the potential learning impact can be maximized.
Raise awareness of sustainable products and services	The CA invests in publicity and promotion of water efficient products and services to raise awareness of the products available and encourage the local community to engage with new water efficient technology. This activity may be complemented by offering subsidies or a rebate to those who are willing to invest in water efficient products.
Leafletting and publicity	The CA funds the distribution of signs and leaflets at the point of water use. Such signage can help to remind consumers about minimizing water use at point of impact. An example sign in a public restroom would read: "Every time you leave a tap running for 10 seconds it wastes X liters."

Possible challenges for implementing this measure include: lack of financial and staff resources; and lack of innovative program design.

Monitoring Metrics

The city authority running a public education campaign should monitor the following measures:

- Number of households claiming subsidies/rebates for purchasing water efficient technologies
- Number of exhibitions and training courses held
- Number of attendees at exhibitions and training courses
- Number and percentage of households receiving leaflets on water efficiency and conservation

Case Studies

Pilot Leak Detection and Abatement Program, Iasi, Romania

<http://www.resourcesaver.com/ewebeditpro/items/O50F1144.pdf>

With an EcoLinks Challenge Grant, Regia Autonoma Judeteană Apa-Canal Iasi (RAJAC) partnered with a U.S. environmental technology provider, Cavanaugh & Associates, to develop a pilot water leak detection and abatement program. The program trained RAJAC personnel in leak detection, implemented a leak detection system, and developed a water conservation program and public outreach campaign. This pilot leak detection and abatement study was a prerequisite for the implementation of a US\$40 million (252.4 million RMB)⁷⁶ infrastructure program. Awareness of new technology was significantly increased through training and seminars. The company's public awareness-raising program encouraged and enhanced consumers' capacity to participate in water conservation efforts. Environmental and economic benefits were derived from the more efficient use of water and energy resources. In the short-term, it was estimated that three of the leaks identified in the pilot scheme were responsible for a water loss of 60,000 cubic meters per year and a revenue loss of US\$24,000 (151,440 RMB). Since the equipment used during the pilot project cost approximately US\$20,000 (126,200 RMB) and no further significant investments were needed to eliminate the leaks, the payback period for the equipment was less than one year. This project contributes to a larger effort to improve water efficiency throughout Iasi County that will ultimately reduce water loss by 8 million cubic meters and provide a savings of US\$3 million (18.9 million RMB) per year, however, this level of savings, would require significant investment in the infrastructure.

Best Practice Sustainable Design, Sydney, Australia

<http://www.sydneywater.com.au/Publications/FactSheets/ESDFeaturesFactsheet.pdf>

<http://www.sydneywater.com.au/Education/EDC/index.cfm>

Sydney Water implements best practices in sustainable design. Their head offices feature water and

⁷⁶ According to the World Bank's official exchange rate of 2012: 1 USD = 6.31 RMB.
<http://data.worldbank.org/indicator/PA.NUS.FCRF>.

energy efficiency as well as recycling. The buildings are designed to achieve a 5 star rating for National Australian Built Environment Rating System (NABERS) and Green Building Council of Australia Green Star Scheme. Both buildings are designed to cut greenhouse gas emissions and reduce drinking water use compared to a typical office building. The Every Drop Counts (EDC) in Schools Program supports schools across Sydney, the Illawarra, and the Blue Mountains by teaching them to value water and to develop water wise practices. Schools in Sydney Water's area of operations use about 7,790 million liters of water a year, which is 6% of all non-residential water use. The EDC in Schools Program helps these schools become water efficient. The resources include: lesson plans, student worksheets, fact sheets about reading water meters and monitoring water use, rainwater tank rebates, templates for water action plans, school water and storm water audits, and games for children to learn about water efficiency.

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
<1 year
- Co-Benefits
Reduced carbon emissions, efficient water use, enhanced public health, increased employment opportunities, financial savings, security of supply

Tools and Guidance

California Department of Water Resources. Water education materials. Available at:

<http://www.water.ca.gov/education/>.

U.S. Environmental Protection Agency. Water conservation practices for homeowners. Available at:

http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specif&bmp=2.

W08: Facility Operator Training Program

Description

Because water/wastewater treatment operations are becoming more complex, completion of an associate degree or one-year certificate program in water quality and wastewater treatment technology is highly recommended. When wastewater treatment plants are properly operated, public health and waters are protected. A certification program helps ensure that operators meet the established requirements and are competent to operate and maintain wastewater treatment plants. Advanced training programs are offered throughout the U.S.

Implementation Strategies and Challenges

Implementation Activity	Description
Take a training course	After submitting the application and paying the training fees, the applicant takes a training course, usually taking several days to weeks. The course will cover in detail the latest strategies and techniques for effective energy management.
Take the certification examination	When finishing the course, the attendee needs to take a certification examination.
Receive the certification	If the attendee successfully passes the certification examination, he/she will be recognized as a certified energy manager by the institution.

Possible challenges for implementing facility operator training program include: lack of training personnel, guidelines and tools, lack of incentives for facility operators to join the program.

Monitoring Metrics

A government body, trade association, or educational institution implementing such a training program should monitor the following measures for its program:

- Number of training participants
- Number of training participants who complete certification
- Employment rates for certified participants
- Total program costs per participant

Case Studies

Wastewater Treatment Plant Operator On-site Assistance Training Program, U.S. Environmental Protection Agency

http://water.epa.gov/learn/training/wwoperatortraining/104g_index.cfm

The program was implemented to address the problem of non-compliance at small publicly-owned wastewater treatment plants, with a discharge of less than 5 million gallons per day, through direct on-site training and other operation and maintenance assistance. Federal funding for the program is administered through grants to states, often in cooperation with educational institutions or non-profit agencies. In most cases, assistance is administered by an environmental training center. In a cooperative effort with EPA, states, state coordinators, municipalities, and operators, the assistance endeavor focuses on issues such as wastewater treatment plant capacity, operation training, maintenance, administrative management, financial management, trouble-shooting, and laboratory operations.

Water Reclamation Plant Operator Training Program, San Bernardino, California, U.S.

http://www.sbcity.org/water/divisions/water_reclamation/water_reclamation_plant_operator_training_program.asp

Wastewater treatment plant operators, certified by the State of California, are responsible for the operation of the facilities. The need for certified operators has created a demand for those who are interested in a career as a wastewater treatment plant operator. The City of San Bernardino Municipal Water Department (SBMWD), in cooperation with San Bernardino Valley College (SBVC), has developed a wastewater operator training program to provide hands on training to SBVC students to meet the minimum one year (2080 hours) experience required to qualify for the Grade 1 Wastewater Treatment Plant Operator certificate.

Water Pollution Control Authority Summer Internship Program, Groton, Connecticut, U.S.

<http://water.epa.gov/infrastructure/sustain/upload/WorkforceFactsheetsCompilation-May-2012.pdf>

The Groton Utilities initiated Water Pollution Control Authority Summer Internship Program since June 2012. This internship program is designed to help young scholars develop an understanding of the skills needed for the wastewater industry. Interns spend the summer before their senior year of high school working a 320-hour internship at the Groton Water Pollution Control Authority (WPCA). Any high school junior in the Groton public school system can apply. All interns, thus far, have been enrolled in the local technical high school. Interns under the age of 18 are insured by the state to work in these safety-sensitive jobs.

In addition to assisting the operator in his/her duties, interns work in the Groton WPCA's lab to help to maintain and monitor equipment. In Groton, interns can take the Sacramento State Operator Training Courses at the local technical high school to supplement their intern experience. Alumni of the summer program are granted the opportunity to participate in a second internship at the plant during their senior year of high school. Interns and managers work together to determine each intern's time commitment for the second internship. All internship hours can count towards earning a Class I wastewater operator certification (Class I is the lowest certification).

Attributes

- Carbon Savings Potential
Low
- First Cost to Government
Low
- Speed of Implementation
<1 year
- Co-Benefits
Improved air quality, enhanced public health, increased employment opportunities, financial savings, reduced waste vehicle traffic

Tools and Guidance

United States Environmental Protection Agency. Wastewater Treatment Plant Operator On-Site Assistance Training Program. http://water.epa.gov/learn/training/wwoperatortraining/104g_index.cfm

California Water Environment Association. Protecting Our Water Environment through Education and Training. http://www.cwea.org/crj_new_howstart_becomeoper.shtml

New York State Department of Environment Conservation. Wastewater Treatment Plant Operator Toolbox. <http://www.dec.ny.gov/chemical/83360.html>

Urban Green Space Policy Recommendations

- U01: Urban Forestry Management
- U02: Urban Green Space

U01: Urban Forestry Management

Description

Urban forests benefit a city in multiple ways, including energy and carbon saving. Trees provide shade and cooling in the hot summer, and buffer cold winds in the winter, saving energy in buildings year-long and off-setting the urban “heat-island” effect (U.S. Forest Service, 2008). Trees create a more sheltered environment for pedestrians and bicyclists, encouraging non-motorized transport and public transport. Trees filter the air for greater health, reducing hospitalizations and lost work from respiratory illness. The air cleaning effect of trees also enables residents to open windows and dry laundry outside, saving more energy. Trees hold rainwater and reducing storm-water runoff, protecting a city’s landscape and waterways, saving water and energy. As storms and weather extremes become more common with climate change, trees are even more valuable as protection for a city. Finally, trees take up carbon from the atmosphere, though this sequestration benefit is small compared to the other benefits of trees.

Implementation Strategies and Challenges

Urban forestry advocates the role of trees as a critical part of urban infrastructure. Planting trees isn’t enough; they must be given good soil, watered, protected from pests, and trimmed as needed. City budgets should include funds for ongoing maintenance. Development plans must include protection and expansion of urban forests. Unlike other public infrastructure components, properly planted and maintained trees increase in value over time. An urban forest management plan, based on recent tree inventory data and analysis of available staff, equipment, and budget resources, is an essential tool for protection of this valuable resource. This plan should include issues related to tree selection and maintenance, a strategy for open/green space development around the city, and an arborist training program to ensure sufficient knowledge and workers exist to maintain the green space. Engaging and educating the public can help to reduce costs and ensure viability of the trees. Carbon trading programs can also help to add value to urban forests, by counting the carbon sequestration provided by the trees.

Possible challenge for implementing urban forestry management plan include: lack of financial and staff resources; lack of data monitoring and collecting system to track the progress of the plan; lack of evaluation reports after the implementation of the plan.

Monitoring Metrics

Some suggested measures that relate specifically to this recommendation are as follows:

- Number of trees planted in the year
- Annual canopy coverage percentage
- Annual reduced heating and cooling demands
- Reduction in Urban heat island temperatures
- Increase in biodiversity

- Per-unit costs and person-hours required for tree establishment, pruning, inspection, removal, and other procedures
- Annual investment costs

Case Studies

Utility-Supported Tree Planting, Sacramento, California, U.S.

<https://www.smud.org/en/residential/customer-service/support-and-services/vegetation-management/tree-planting.htm>

Sacramento Municipal Utility District (SMUD), the publicly owned power company, provides free shade trees to its residents through its contractor, the non-profit, community-based Sacramento Tree Foundation (STF). The shade trees are planted to directly shade buildings. If strategically sited and mature, the trees help reducing air-conditioning demand by up to 40%. The long-term program objective is to mitigate the urban heat island effect, thereby conserving energy resources and reducing air pollution resulting from power generation. Since its inception in 1990, SMUD's Shade Tree Program has given about 375,000 shade trees away to city residents until 2006. At the end of 2002, these shade trees were reducing an estimated 1.95 MW and 4.8 GWh annually in direct cooling load.

Great Tree Canopy Comeback, Fort Wayne, Indiana, U.S.

<http://www.fortwayneparks.org/>

Through a program named the Great Tree Canopy Comeback, Fort Wayne is working to restore and supplement a lush tree canopy and to increase the city's ability to absorb CO₂ emissions. The successful publicity campaign led to a successful private fund raising effort, the allocation of City funds to the initiative, and the rallying of volunteers who assist Parks staff and contractors in the actual planting of trees. The City uses its purchasing power to buy trees from private nurseries at bulk rates; this, coupled with the use of volunteers, results in a very low cost-per-tree for landscape-size trees. Funding sources include private donations, Community Economic Development Income Tax funds, and the City Parks budget. A single mature tree absorbs roughly 48 pounds of CO₂ per year. Thus, the approximately 1,000 trees planted since the program began absorb roughly 48,000 pounds of CO₂ annually. Eventually, the City would like to include park trees in a carbon registry.

Tree Canopy Remediation and Replenishment, Miami, Florida, U.S.

<http://miami-dade.ifas.ufl.edu/pdfs/disaster/Hurricane%20Preparation%20files/City%20of%20Miami%20Master%20Plan.pdf>

In 2002 Miami launched a comprehensive and aggressive environmental program to reverse decades of neglect; the aim is to improve climate protection and the City's livability by implementing sustainable urban design principles. Tree canopy remediation and replenishment are key components of this effort. The City is working to increase its tree canopy to 30 percent from its current 7 percent and conducting a comprehensive analysis of the tree canopy in partnership with American Forests. Working with community groups, the private sector, and various government agencies, Miami is well on its way to meeting its goals. A Tree Trust Fund has been created to fund special greening projects on an on-going basis. Proceeds from fines and tree planting permits are dedicated to greening initiatives. To date, the Tree Trust Fund has generated over \$667,000 (4.2 million RMB)⁷⁷.

Attributes

- Carbon Savings Potential

Low

Protocols are available to estimate the direct carbon savings from urban trees through carbon sequestration, as well as indirect savings. For example, the California Climate Action Registry has a protocol for sequestration benefits (CCAR 2010), while the Tree Carbon Calculator (CTCC) developed by the Urban Ecosystems and Processes Team of the U.S. Forest Service estimates both direct and indirect savings (U.S. Forest Service Tree Carbon Calculator; SMUD Tree Benefit Estimator). Carbon sequestration in urban trees varies from 16 kg/year per tree for small, slow-growing trees, to 270 kg/year for larger trees.¹²⁴ Urban forest in the city of Portland currently covers 26 percent of the city and removes 88,000 metric tons of CO₂ from the atmosphere per year, equivalent to about one percent of local carbon emissions.¹²⁵

The indirect savings of energy, carbon, and money from trees includes those from shading and insulation and natural ventilation. These indirect savings from urban trees can reduce summer cooling demand from 8-43% (U.S. Forest Service, 2008). In regions with cold winters and hot summers, overall indirect carbon savings were 3-15% from shading, evapotranspiration, and wind speed reduction on residential buildings, depending on the electricity generation mix and the positioning of tree cover (Jo and McPherson, 2001).⁷⁸ Difficult to quantify are the additional benefits of cleaner air for clothes drying, and encouraging non-motorized transit with tree-protected pathways.

- First Cost to Government

Low

Indirect benefits should be taken into account as well as direct carbon savings in determining cost effectiveness of urban tree planting and maintenance. Note that direct carbon savings (through sequestration) are relatively small compared to other low-carbon policy actions (such as industrial or building efficiency improvements), and the sequestration-only cost-effectiveness is low. However, the indirect energy savings and health benefits from urban trees make them highly valuable.

⁷⁷ World Bank official exchange rate of 2012: 1 USD = 6.31 RMB. <http://data.worldbank.org/indicator/PA.NUS.FCRF>.

⁷⁸ In cold climates, plant trees densely on the north side of buildings, close to the west wall, and avoid on the south wall.

- Speed of Implementation
3 years
- Co-Benefits
Fuel savings, improved air quality, water retention, enhanced public health

Tools and Guidance

Urban & Community Forest Management Plan & Guidebook. Available at:

<http://www.na.fs.fed.us/urban/inforesources/mgmtplanguide/mgmtplanguide.shtml>.

Urban Forestry Best Management Practices for Public Works Managers: Urban Forest Management Plan. American Public Works Association. Available at:

<http://www2.apwa.net/documents/About/CoopAgreements/UrbanForestry/UrbanForestry-4.pdf>.

Urban Forest Management Plan Toolkit. Available at: <http://ufmptoolkit.com/>.

A Technical Guide to Urban and Community Forestry. Available at:

<http://www.na.fs.fed.us/spfo/pubs/uf/techguide/toc.htm>.

Tools for Assessing and Managing Community Forests. Available at: <http://www.itreetools.org/>.

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<http://www.climateactionreserve.org/how/protocols/urban-forest/>

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Portland, City of, and Multnomah County. 2009. Climate Action Plan. Online:

<http://www.portlandoregon.gov/bps/49989> in Chinese:

<http://www.portlandoregon.gov/article/334623>

Sacramento Municipal Utility District (SMUD). Tree Benefit Estimator. Simple web-based protocol for direct and indirect carbon savings of urban trees. Online: <https://usage.smud.org/treebenefit/>

U.S. Forest Service. 2008. "Urban Forest Greenhouse Gas Reporting Protocol." Available at:

http://www.fs.fed.us/psw/programs/cufr/products/12/psw_cufr742_UrbanForestProtocol.pdf

U.S. Forest Service. Tree Carbon Calculator. Online: <http://www.fs.fed.us/ccrc/tools/ctcc.shtml>

U02: Urban Green Space

Description

Urban green spaces—on the ground and on roof-tops—are essential for energy and carbon savings across multiple initiatives in a city’s low-carbon development plan. Green spaces are “green infrastructure,” providing live-ability and buffering of the urban heat-island effect, reducing the need for building cooling and heating. Green spaces create more permeable surfaces, for better management of storm-water runoff, protecting a city’s infrastructure, which saves energy and carbon from construction and maintenance. Green spaces encourage non-motorized transport and public transportation, reducing emissions from the transportation sector. Roof-top green spaces provide insulation for buildings, reducing energy demand for heating and cooling.

Green spaces enable a city to better adapt to changing climate, by providing cool spaces, off-setting the urban heat island effect, buffering against storms and gathering rainwater, reducing air pollution, and growing plants suited to an altered climate (City of Chicago 2009). Urban green spaces can also be used for organic urban gardens, providing local and healthy food to city residents.

Implementation Strategies and Challenges

- **Increase the amount** of per capita green space, including parks, open public spaces, green preserves along water corridors, greenways connecting parks and preserves, and roof-top gardens.
- **Set goals** for public access to green space—every resident within 15 minutes of a park.
- Recognize parks and preserves as “**green infrastructure**,” protecting the city’s transport systems, water and flood protection systems, buildings, and biodiversity.
- Include **investment** for managing, restoring, and expanding green space.
- Encourage **roof-top green spaces**, for gardens, rainwater management, and energy saving.

Monitoring Metrics

Some suggested measures that relate specifically to this recommendation are as follows:

- Area of urban green space, total and per capita (grass vs. forest, ground-level vs. roof-top).
- Percent of population within 15 minutes of green space.
- Annual reduced heating and cooling demands in green roof buildings.
- Utilization rates of public green spaces.
- Reduction in Urban heat island temperatures near green spaces and green roofs.

Case Study

PlaNYC and Urban Green Space, New York City

PlaNYC has the goal of putting all New Yorkers within a 10-minute walk of a park. New York thus far has more than 52,000 acres of City, state and federal parkland, covering 25% of the city's area (New York City 2011 and 2012). The Brooklyn waterfront facing Manhattan has been revitalized with a greenway, playground, outdoor dining, and wetlands. One of the most innovative parks in the city is the High Line, which turned an abandoned elevated freight rail line into a Manhattan green space highlight (High Line). This above-ground park saved embodied energy and carbon by re-purposing old transport infrastructure, transforming it into a public gathering space and a living work of art. As another example, roof-top green space on the large New York Postal Service facility in Manhattan is saving 40% of energy demand and reducing polluted storm water by 75% in summer and 40% in winter (Greenbiz News 2010).

Attributes

- Carbon Savings Potential

Low

The carbon savings potential varies with the type of green space. Urban green spaces may provide a small amount direct carbon sequestration, offering a small offset of city greenhouse gas emissions. In terms of direct savings, energy and carbon savings of 40-75% have been achieved in buildings with roof-top green space, depending on the location's climate and the type of green roof (NREL and U.S. DOE, 2004). Urban green spaces also support indirect carbon savings in the transportation sector, by creating appealing spaces for walking, biking, and public transit.

- First Cost to Government

Low

From Chicago to New York, cities recognize that green spaces, specifically access to parks and open spaces, improve public health, increase the value of real estate, and attract businesses to the regional economy (CMAP 2010; Jo and McPherson 2001). The direct energy and carbon savings may be small, but green spaces enable large indirect benefits. While costs and savings are difficult to quantify, the multiple benefits of green spaces as "green infrastructure" likely contribute net economic savings for a city.

- Speed of Implementation

1 - 3 years

- Co-Benefits

Fuel savings, improved air quality, improved water management, enhanced public health, economic savings in urban infrastructure maintenance

Tools and Guidance

Leibniz Institute of Ecological Urban and Regional Development (IOER). A Strategy for Urban Green Space. Online:

www.ioer.de/greenkeys/Greenkeys_Tools/files_manual/GreenKeys_manual_Chap_2_250808.pdf

U.S. Environmental Protection Agency (U.S. EPA). Green Infrastructure: Energy and Climate Change.

Online: http://water.epa.gov/infrastructure/greeninfrastructure/gi_why.cfm#EnergyClimateChange

World Bank. 2010. Building Urban Resilience: Principles, Tools, and Practice. Abhas K. Jha, Todd W. Miner, Zuzana Stanton-Geddes, editors.

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New York City. 2012. PlaNYC Progress Report 2012

Appendix 1. Attributes & Capability Requirements for 72 Policy Recommendations

Building Policy Recommendations	Sector	Policy Attributes			Capability Requirements		
		Speed of implementation	First Cost to Government	Carbon Savings Potential	Finance	Human Resources	Enforcement
B01: Energy-Efficient Equipment and Renewable Energy Technology Purchase Subsidies	Residential	1-3years	High	High	High	Medium	Medium
B02: Subsidies for New Buildings that Exceed Building Code	Both	1-3years	High	Medium	High	High	Medium
B03: Retrofit Subsidies and Tax Credits for Existing Buildings	Both	1-3years	High	Medium	High	Medium	Medium
B04: Cooperative Procurement of Green Products	Commercial & Public	<1year	Low	Low	High	High	Medium
B05: Energy Performance Contracting and Energy Service Companies	Commercial & Public	<1year	Low	Low	Medium	Medium	Medium
B06: Municipal Building Energy Efficiency Task Force	Commercial & Public	<1year	Low	Low	Low	High	Medium
B07: Expedited Permitting for Green Buildings	Both	<1year	Low	Low	Low	Medium	Medium
B08: Targets for Efficient and Renewables in Buildings	Both	1-3years	Low	Medium	Low	Medium	Medium
B09: More Stringent Local Building Codes	Both	>3year	Medium	High	Low	Medium	High
B10: Green Building Guidelines for New Buildings	Both	<1year	Low	Medium	Low	Medium	High
B11: Financial Incentives for Distributed Generation in Buildings	Commercial & Public	1-3years	Medium	Medium	Medium	Medium	High

B12: City Energy and Heat Maps	Both	<1year	Low	Low	Low	Medium	Low
B13: Building Energy Labeling and Information Disclosure	Both	1-3years	Low	Medium	Low	Medium	Low
B14: Mandatory Building Energy-Efficiency Audit and Retrofits	Commercial & Public	1-3years	Medium	Medium	Medium	Medium	Medium
B15: Reach Standards for Efficient Appliance and Equipment	Residential	1-3years	Low	High	Low	Low	Low
B16: Building Workforce Training	Residential	<1year	Low	Low	Low	Medium	Low
B17: Public Education Campaigns on Building Energy Efficiency and Conservation	Both	<1year	Low	Low	Low	Medium	Low

Industry Policy Recommendations	Speed of implementation	First Cost to Government	Carbon Savings Potential	Finance	Human Resources	Enforcement
I01: Benchmarking	<1year	Low	Medium	Low	Medium	Low
I02: Energy Audit / Assessments	1-3years	Medium	Medium	Low	Medium	Low
I03: Industrial Energy Plan	<1year	Low	Medium	Low	Medium	Low
I04: Stretch Targets for Industry	1-3years	Low	Medium	Low	Medium	Medium
I05: Subsidies and Rewards for Industrial Energy Efficiency	1-3years	High	Medium	High	High	Medium
I06: Industrial Energy Efficiency Loans and Innovative Funds	>3years	High	Medium	High	Medium	Medium
I07: Tax Relief	1-3years	High	Medium	High	High	High
I08: Energy or CO ₂ Tax	1-3years	Low	High	High	High	High
I09: Industrial Equipment and Product Standards	1-3years	Low	Medium	High	High	High
I10: Differential Electricity Pricing	<1year	Low	Medium	High	High	High
I11: Energy Management Standards	<1year	Medium	Medium	Low	Medium	Low

I12: Energy Manager Training	<1year	Medium	Medium	Low	Medium	Low
I13: Recycling Economy and By-product Synergy Activities	1-3years	Medium	Medium	Medium	Medium	Medium
I14: Low-carbon Industrial Parks	>3years	Medium	Medium	Medium	High	Medium
I15: Fuel-switching	1-3years	High	High	Low	Low	Low

Power Policy Recommendations	Speed of implementation	First Cost to Government	Carbon Savings Potential	Finance	Human Resources	Enforcement
P01: Minimum Performance Standards for Thermal Power Plants	1-3years	Medium	High	High	High	High
P02: Renewable Energy and Non-fossil Energy Targets or Quotas	>3years	Low	High	High	High	High
P03: District Heating Networking Maintenance and Upgrade Program	1-3years	Medium	Medium	Medium	Medium	Low
P04: Transformer Upgrade Program	<1year	Medium	Medium	High	High	High
P05: Time-based Electricity Pricing Schemes: Inclining Block Pricing and Time-of- Use Pricing	1-3years	Medium	Medium	High	High	High
P06: Load Curtailment Incentives/Demand Response/Curtailable Rates	1-3years	Medium	Medium	High	High	High
P07: Power Investment subsidies and tax incentives for Renewable Energy	1-3years	High	High	High	High	High

Street Lighting Policy Recommendations						
SL01: Street Lighting Plan	<1year	Low	Low	Low	Medium	Low
SL02: Audit and Retrofit Programs	<1year	Low	Low	Medium	Medium	Low

Solid Waste Policy Recommendations				Speed of implementation	First Cost to Government	Carbon Savings Potential	Finance	Human Resources	Enforcement
SW01: Integrated Solid Waste Management Planning				<1year	Low	Low	Low	Medium	Low
SW02: Recycling and Composting Mandate and Program				1-3years	Low	Low	Medium	Medium	Low
SW03: Landfill Methane Recovery				1-3years	Medium	Low	Medium	Medium	Medium
SW04: Anaerobic Digestion				1-3years	Low	Low	Medium	Medium	Medium
SW05: Waste Composting Program				1-3years	Low	Low	Medium	Medium	Medium
SW06: Waste Vehicle Fleet Maintenance, Audit and Retrofit Program				<1year	Low	Low	Low	Low	Low
SW07: Public Education Program				<1year	Low	Low	Low	Medium	Low

Transportation Policy Recommendations				Speed of implementation	First Cost to Government	Carbon Savings Potential	Finance	Human Resources	Enforcement
T01: Integrated Transportation Planning				>3year	Low	Medium	Low	Medium	Low
T02: Mixed-use Urban Form				>3year	Low	Medium	Low	Medium	Low
T03: Vehicle CO2 Emission Standards				1-3years	Medium	High	High	High	High
T04: Vehicle Fuel Economy Standards				1-3years	Medium	High	High	High	High
T05: Commuting programs				<1year	Low	Medium	Low	Low	Low
T06: Bike Share Programs				1-3years	Low	Low	Low	Low	Low
T07: Improved Bicycle Path Network				1-3years	Medium	Medium	Low	Low	Low
T08: Complete Streets				1-3years	Low	Low	Low	Low	Low
T09: Public Transit Infrastructure: Light rail, BRT, and Buses				>3year	Medium	High	High	Medium	Medium

T10: Congestion Charges, and Road Pricing	1-3years	Low	Medium	High	Medium	Medium
T11: Parking Fees and Measures	1-3years	Low	Medium	Medium	Medium	Medium
T12: Vehicle License Policies	<1year	Low	Medium	Low	Low	Medium
T13: Public Education on Transport Options	<1year	Low	Low	Low	Medium	Low
T14: Clean Vehicle Program	1-3years	Medium	Medium			

Water Policy Recommendations	Speed of implementation	First Cost to Government	Carbon Savings Potential	Finance	Human Resources	Enforcement
W01: Water Management Plan	<1year	Low	Low	Low	Medium	Low
W02: Codes, Consumer Education, and Incentives for Water-Efficient Products	<1year	Low	Low	Low	Medium	High
W03: Prioritize Energy Efficient Water Resources	1-3years	Low	Low	Low	Medium	Medium
W04: Improve Efficiency of Pumps and Motors	1-3years	Medium	Medium	Low	Medium	Low
W05: Active Leak Detection and Pressure Management Program	1-3years	Low	Low	Low	Medium	Low
W06: Methane Capture and Reuse/Conversion	<1year	Low	Low	Medium	Medium	Medium
W07: Public Education Measures	<1year	Low	Low	Low	Medium	Low
W08: Facility Operator Training Program	<1year	Low	Low	Low	Medium	Low

Urban Green Space Policy Recommendations						
U01: Urban Green Space Program	<1year	Low	Low	Low	Medium	Low
U02: Urban Forestry Management Program	>3year	Low	Low	Low	Medium	Medium

Appendix 2. Policy Attributes and Numerical Ranges based on City Size

Speed of Implementation:

Low < 1 year; Medium 1-3 years; High > 3 years

Carbon Impact Potential (in annual tonnes CO₂e, varies with size of city):

	Population				
	< 500,000	500,000 – 999,999	1 million – 4,999,999	5 million – 9,999,999	>10 million
Low	<50,000	<125,000	<250,000	<500,000	< 1 million
Medium	50,000 – 249,999	125,000 – 625,000	250,000 -1.25 million	500,000 – 2.5 million	1 – 5 million
High	>250,000	>625,000	>1.25 million	>2.5 million	>5 million

First Cost to Government (in RMB; varies with size of city):

	Population				
	< 500,000	500,000 – 999,999	1 million – 4,999,999	5 million – 9,999,999	>10 million
Low	<500,000	<1.25 million	<2.5 million	<5 million	< 10 million
Medium	500,000 – 5 million	1.25 million – 12.5 million	2.5 million – 25 million	5 million – 50 million	10 million – 100 million
High	>5 million	>12.5 million	>25 million	>50 million	>100 million