Building Efficiency Accelerator

BERKELEY LAB
Bringing Science Solutions to the World

Targets Playbook

Carolyn Szum, Jing Hou, Nan Zhou

Lawrence Berkeley National Laboratory

March 2020

Table of Contents

Acronyms v

CHAPTER 1 1

INTRODUCTION 2

I. ASSESS 3

Assess A: Collect Existing Resources and Information 3

Assess A: Case Study on Collecting Existing Resources and Information 3

Assess A: Additional Guidance on Collecting Existing Resources and Information 6

Assess B: Understand Benefits and Potential Barriers 7

Assess B: Case Study on Understanding Benefits and Potential Barriers 10

Assess C: Identify Stakeholders, Tools and Resources Needed 12

Assess C: Case Study on Identifying Stakeholders and Assigning Roles 14

II. DEVELOP 17

Develop A: Define Scope of the Policy or Measure 17

Develop A: Case Study on Defining the Scope 17

Develop B: Develop Locally Appropriate Policy, Building on National, Regional, or Global Models 18

Develop B: Case Study on Developing Locally Appropriate Policy, Building on National, Regional, or Global Models 19

Develop C: Adopt Policy 20

Develop C: Case Study on Adopting a Policy 20

Develop D: Develop Implementation Plan 21

Develop D: Case Study on Developing an Implementation Plan and Timeframe 21

III. IMPLEMENT 23

Implement A: Implement Energy Saving Actions 23

Implement A: Case Study on Implementing Energy Saving Actions 23

Implement B: Monitor Progress and Make Adjustments, Taking Immediate Action to Resolve Problems that Arise 25

Implement C: Showcase Results to Stakeholders and the Public 26

Implement C: Case Study Showcasing Results to Stakeholders and the Public 27

IV. IMPROVE 29

Improve A: Review and Evaluate Implementation, Impacts, and Potential 29
Improve A: Case Study on Reviewing and Evaluating Implementation, Impacts, and Potential 29
Improve B: Analyze Evaluation Results and Assess Next Steps 30
Improve B: Case Study on Analyzing Evaluation Results and Assess Next Steps 31
CONCLUSION 32
CHAPTER 2 33
About Changning District, Shanghai, China 34
I. ASSESS 36
Assess A: Collect Existing Resources and Information 36
Activity 1: Assess Existing Targets 36
Activity 2: Assess Existing Policies and Programs 36
Activity 3: Assess Available Data 38
Assess B: Understand Benefits and Potential Barriers 41
Activity 1: Assess Benefits 41
Activity 2: Assess Barriers 42
Assess C: Identify Stakeholders, Tools, and Resources Needed 43
Activity 1: Identify Stakeholders and Assign Roles 43
Activity 2: Identify Tools and Resources 45
II. DEVELOP 46
Develop A: Define Scope of the Policy of Measure 46
Activity 1: Select the Type of EBEE Targets and Improvement Program 46
Activity 2: Evaluate Various Approaches to Establishing EBEE Targets 51
Activity 3: Estimate the Costs and Impacts of the Program 52
Activity 4: Determine on Which Buildings the Program Will Be Implemented 53
Develop B: Develop Locally Appropriate Policy, Building on National, Regional, or Global Models 54
Activity 1: Develop Policy Options 54
Develop C: Adopt Policy 55
Activity 1: Set EBEE Targets by Building Type 55
Activity 2: Select Policies to Facilitate the EBEE Targets and Improvement Program 57
Develop D: Develop Implementation Plan 61
Activity 1: Develop an Implementation Plan and Timeframe 61
III. IMPLEMENT 63

Implement A: Implement Energy Savings Actions 63
Activity 1: Analysis on Possible Problems might exist during the Implementation Process of the EBEE Program 63
Activity 2: Develop Project Management Processes for the EBEE Program 63
Implement B: Monitor Progress and Make Adjustments, Taking Immediate Action to Resolve Problems that Arise 65
Activity 1: Monitor Progress 65
Activity 2: Build Feedback Mechanisms to Resolve Problems that Arise 65
Implement C: Showcase Results to Stakeholders and the Public 66
Activity 1: Showcase to Stakeholders 66
Activity 2: Public What Results have been Achieved 66
IV. IMPROVE 68
Improve A: Review and Evaluate Implementation, Impacts, and Potential 68
Activity 1: Continually Extend and Improve the ECMP 68
Activity 2: Update the CO_2 abatement Cost Curve based on Real Data 69
Improve B: Analyze Evaluation Results and Assess Next Steps 70
References 72
Appendix 74

Acronyms

BEA	Building Efficiency Accelerator
BEM	Building Energy Modeling
BETTER	Building Efficiency Targeting Tool for Energy Retrofits
BPIE	Building Performance Institute Europe
BTUS	Building Technologies and Urban Systems
C40	The C40 Cities Climate Leadership Group
CABEE	China Association of Building Energy Efficiency
CBP	China Building Programme
CO_2	Carbon Dioxide
DCAS	Department of Citywide Administrative Services
DOE	Department of Energy
ECADI	East China Architectural Design Institute
ECB	Existing Commercial Building[1]
EBEE	Existing Building Energy Efficiency
ECSP	Energy Consumption Supervision Platform
ECMP	Energy Consumption Monitoring Platform
EE	Energy Efficiency
EFC	Energy Foundation China
EIS	Energy Information System
EMIS	Energy Management Information System
EMS	Energy Monitoring System
EPBD	Energy Performance Building Directive
EPC	Energy Performance Contract
ESCO	Energy Service Company
ESMAP	Energy Sector Management Assistance Program
ETDZ	Economic and Technological Development Zone
EU	European Union
EUI	Energy Use Intensity
FIRR	Financial Internal Rate of Return
FREE	Regional Fund for Energy Efficiency
FYP	Five-Year Plan
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GOC	Government of China
HQBD	Hongqiao Business District
HVAC	Heating, ventilating, and air-conditioning
IOSM	Information Office of Shanghai Municipality
KgCE	Kilograms of Coal Equivalent
km^2	Square Kilometers
KPI	Key Performance Indicator
kWh	Kilowatt-hour

[1] Non-residential buildings used for commercial purposes, such as hotels, commercial offices, or shopping malls. Commercial buildings are referred to as public buildings in China.

LBNL	Lawrence Berkeley National Laboratory
LCA	Life-cycle Assessment
LTRS	Long-term Renovation Strategies
M&V	Measurement and Verification
m^2	Square Meters
m^3	Cubic Meters
MAC	Marginal Abatement Cost
MIIT	Ministry of Industry Information and Technology
Mtce	million tons of coal equivalent
$MtCO_2e$	metric tons of carbon dioxide equivalent
MOF	Ministry of Finance
MOHURD	Ministry of Housing and Urban-Rural Development
NOI	Net Operating Income
NPV	Net Present Value
O&M	Operations and Maintenance
PIP CAT	Project Implementation Plan – Computer Aided Tool
RE	Renewable Energy
RMB	Renminbi
ROI	Return on Investment
SABR	Shanghai Academy of Building Research
SECAP	Sustainable Energy and Climate Action Plans
SECSC	Shanghai Energy Conservation Supervision Center
SHPDDB	Shanghai Pudong Development Bank
SHB	Shanghai Bank
SMDRC	Shanghai Municipal Development and Reform Commission
TCE	Tons of Coal Equivalent
TSC	Tons of Standard Coal
URLCPMC	Urban Renewal and Low Carbon Project Management Center
WRI	World Resources Institute
ZagEE	Zagreb Energy Efficient City Project

Chapter 1

General Guidance for Cities

Introduction

While defining energy-efficient, high-performance buildings through codes can be considered the foundation of a successful energy efficiency market transformation program, voluntary energy efficiency targets for existing buildings provide critical direction and momentum. They not only encourage buildings to be operated at significantly reduced energy usage level, but they also incentivize the buildings industry (designers, developers, owners, managers, and service providers) to introduce innovative strategies and technologies to deliver large volumes of energy-efficient, high-performance buildings, thereby increasing the cost-effectiveness of these buildings over time. Moreover, voluntary existing building energy efficiency (EBEE) targets and improvement programs reduce existing building energy usage, costs, and greenhouse gas (GHG) emissions, while simultaneously creating new jobs and increasing business for energy service companies (ESCO) (Navigant et al., 2015; Burr et al. 2013).

This *Targets Playbook* aims to assist cities and districts globally to develop and implement voluntary EBEE targets and improvement programs. Chapter 1 provides step-by-step, case study-based guidance to assist cities to establish EBEE targets and improvement programs through four stages: assessment, development, implementation, and improvement, as outlined in Figure 1 below. In each stage, the *Targets Playbook* provides an overview of questions for cities to consider, as well as possible approaches for cities to take based on real-world case studies. Wherever possible, useful resources are provided to help cities get started. Chapter 2 provides an in-depth review of the case study of Changning District, a leading low-carbon district in Shanghai, China, which successfully implemented a voluntary EBEE targets and improvement pilot program between 2013 and 2018. The case study provides a detailed example of how a district helped 45 commercial buildings reduce energy consumption by 25,423,662 kilowatt hours (kWh) and avoid 63,285 tons of carbon dioxide (CO_2) emissions through an EBEE targets and improvement pilot program (SABR 2019).

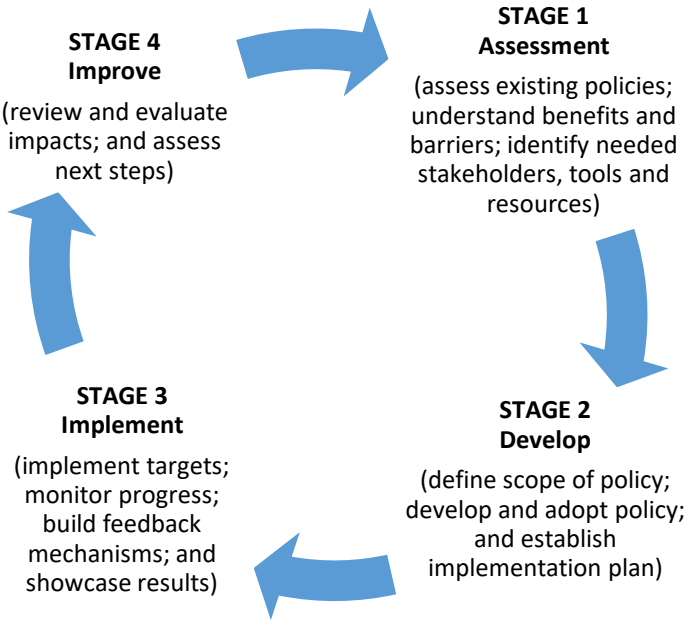

Figure 1. Stages for Establishing an EBEE Targets and Improvement

I. ASSESS

1.1 Collect Existing Resources and Information

Assessment is the first stage in establishing a voluntary EBEE targets and improvement program and typically involves three components: collecting existing resources and information; understanding benefits and potential barriers; and identifying stakeholders, tools, and resources needed for implementation. To get started collecting existing resources and information, cities will want to answer the questions below pertaining to existing targets, policies and programs, and data sources that could be leveraged for a successful city initiative. Suggested questions include:

- Are there any national, provincial, or local city-level energy or GHG emissions reductions targets for the building sector?
- If so, to what extent are the national, provincial, local level targets consistent?
- If so, what are the targets, and how is progress towards the targets measured?
- What mandatory and voluntary EBEE policies and programs are in place, or planned, at a national, provincial, or city-level? For instance, what codes, standards, regulations, incentives, training, information programs, etc. exist or are planned?
- What achievements in building energy conservation and efficiency improvement have been reached as a result of these policies and programs?
- How would a voluntary EBEE targets and improvement program fit into the existing framework of policies and programs? For instance, could national financial incentives or subsidies be leveraged?
- Is there an inventory of the existing building stock of the city?
- Are data on the characteristics (e.g., size, location, type, construction year) and energy usage of existing buildings (e.g., monthly or annual energy consumption by fuel type) collected, cleansed, organized, stored, and analyzed in the city?
- If so, what data are collected, by whom, how often, in what format, and for how many buildings of which types?
- Where is the data stored, and what analyses are conducted on the data?
- If not, where and how could one obtain the necessary data and information above?[2]

Case Study: Collecting Existing Resources and Information

In an effort to transition to a leading low-carbon district in Shanghai, China, an initial question raised by the Changning District government was: are there any national or local energy or GHG emissions reductions targets for the building sector that we can leverage and/or align with to help establish a voluntary EBEE targets and improvement program? Through desk research and stakeholder engagement, the Changning District identified the following:

- ***Chinese national energy and GHG emission reduction targets***. The government of China's (GOC) commitment to reducing national CO_2 intensity by 40-45% from 2005 to 2020. Energy efficiency (EE) and renewable energy (RE) were expected to contribute significantly to achieving this target.

[2] It is suggested that cities review the data types and sources described in Tables 3 and 4 and conduct a mapping exercise to determine what data can be obtained for their city most readily.

In addition, under the 12th Five-Year Plan (FYP) (2011-2015), China committed to cutting energy intensity by 16% and increasing the share of non-fossil fuels (RE and nuclear) in primary energy from 8% in 2011 to 15% by 2020.

- ***Shanghai's low-carbon target***. The Shanghai municipal government included "transition to a low-carbon city" as one of the high priorities of their 12th FYP (SECSC et al. 2013).
- ***Changning District's low-carbon target***. The Changning District government presented a vision of transforming Changning District into a leading low-carbon district in Shanghai and China. In 2011, Hongqiao Business District, belonging to Changning, was selected as one of the eight low-carbon demonstration areas in Shanghai (World Bank 2013).

Once relevant targets had been identified, Shanghai's Changning District undertook a comprehensive review of national, provincial, and municipal building EE programs and policies. This included:

- National building EE codes and retrofit policies, and financial incentives.
- Shanghai building EE codes, retrofit policies, and financial incentives.
- Building EE codes, retrofit policies, and financial incentives from other Chinese cities and foreign countries, provinces, and cities.
- Achievements from various building EE policies and programs.
- Current municipal building EE retrofit business models (SECSC et al 2013).

Some key results of Changning District's assessment are shown in Table 1 below:

Table 1. Chinese National and Shanghai Municipal Building EE Policies

No.	Title of Policy	No.	Title of Policy
1	Energy Conservation Law	5	Contract Energy Management Project Financial Incentives Fund
2	Law of the People's Republic of China on Renewable Energies	6	*Special Fund* Management Interim Measures for Government Office Buildings and Large Public Building Energy-Saving
3	Civil Building Energy Saving Regulations	7	Notice on Further Promoting the Public Building Energy Saving Work
4	Regulations on Energy Conservation of Public Institutions	8	Notice on Further Promote Renewable Energy Application in Buildings
9	Shanghai Energy Conservation Ordinance	10	Shanghai Special Support Measures for Renewable and New Energy Development

Source: SECSC et al. 2013.

Lastly, Changning District assessed available data for the district. One of the preconditions for Changning District, Shanghai's EBEE targets and improvement program was to establish and utilize the Commercial Building Energy Consumption Monitoring Platform (ECMP), which is shown in Figure 2.

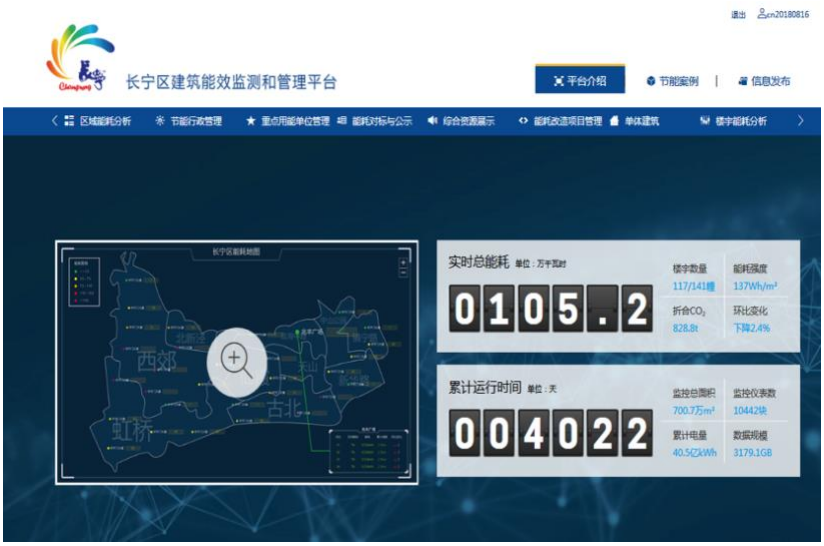

Figure 2. Changning District ECMP interface. Source: SABR 2019, 9.

As an integrated online platform, ECMP enabled the real-time monitoring, analyses, processing, exchange, and public disclosure of energy consumption data for large commercial buildings in the area. (Wu 2019). At that time of the EBEE targets and improvement program, the Changning District ECMP was connected to 100 commercial buildings, which covered 63% of commercial buildings across the district, and monitored hundreds of millions of kWh of electricity consumption each year (EFC (a) 2012). The data collected through the Changning District ECMP included:

- Building Characteristics:
  - Location (e.g., address)
  - Type and function (e.g., office building, shopping mall, hotel, cultural and education building, hospital, sports building; mix-used building)
  - Building size (i.e., including gross floor area and indoor garage floor area)
  - Construction year (e.g., before 1990; 1991-1995; 1996-2000; 2001-2010; or 2011-present)
  - Occupancy (e.g., number of users of electricity)
- Building Energy Data:
  - Total building energy consumption and energy consumption per unit of floor area
  - Energy consumption by end-uses/system (e.g., air conditioning electricity, power electricity, lighting electricity, special electricity, elevator, plug, etc.)
  - Energy consumption by fuel type (e.g. electricity, thermal/heat energy, natural gas, solar power, etc.)
- Other:
  - Building water consumption data
  - Building retrofit information[3] (e.g., project name, demonstration retrofit floor area, retrofit extent, energy savings, energy saving rate) (Zhu and Xu 2016; Chen 2014) (SABR 2019).

[3] This function was developed in Shanghai after they initiated the EBEE targets and improvement program.

Additional Guidance on Collecting Existing Resources and Information

While Changning District took a very comprehensive approach to data collection and assessment, all cities may not have sufficient resources to take this approach. The minimal recommended data points for a city to collect are shown in Table 3 below. With just these simple data points for at least 50 buildings of a single type (e.g., office, hotel, elementary school), free, open-source, online tools, such as Lawrence Berkeley National Laboratory's (Berkeley Lab) Building Efficiency Targeting Tool for Energy Retrofits (BETTER), can be used to establish energy savings targets for a single building, portfolio, district, or city. [4]

Table 3. Suggested Minimum Data Points to Establish Targets

Data Point	**Description**
Contact Person	Building owner, property manager, or building manager.
Property Identification Number	Integer number used to differentiate between individual buildings.
Property Location	City, state/province, and country.
Gross Floor Area (Excluding Parking)	this is the gross floor area of the building as measured between the principal exterior surfaces.
Primary Building Space Type:	The primary function assigned to the building space, such as hotel, office, hospital, elementary school, etc.
Energy Data	At least 12 consecutive months of energy usage for all fuels used in the building (electricity - grid purchased, natural gas, diesel, purchased hot water, purchased steam, etc.), including monthly billing start date, monthly billing end date, energy type, and energy unit.

Source: LBNL 2019.

For cities just getting started with data collection, standard sources of data for cities to investigate in order to collect a sufficient amount of data to assess their building stock, are shown in Table 4 below.

Table 4. Typical Building and Energy Data Sources

Type	**Description**
Land / tax data	A description of land parcels obtained from a government entity. Should have information about the property owner but may not have information about the building owner or characteristics of buildings that are on the property.
Research data	Data from universities and research institutions.
Private consultants	Data that may have been collected by private consultants. However, there may be restrictions on sharing data.
Government data	City, county/province, state, national departments often have building and energy data. Consider discussing government data sources with the city administrator's office, sustainability or environmental protection offices, housing or community development offices, the general services or public works offices, etc.

[4] A data collection template and online training can be provided by World Resources Institute (WRI) Building Efficiency Accelerator (BEA) to cities to help get started collecting data and setting targets using BETTER.

Real estate data	Data that has been collected with regard to potential or recent real estate sales transactions, and which is available for sale. Typically has information about building location, size, type, owners, and managers.
Energy data from building owners, facility managers, and ESCOs	Monthly energy consumption values, by energy type, along with building location, size, and type, can be accessed from a building owner, manager, or ESCO from their utility billing information,
Energy Monitoring Systems (EMS) and smart meters	Buildings may have installed automated EMS and "smart meters", which collect energy data at short 15-minute intervals.
Energy data from energy provider / utility data (automated)	Utilities may have programs which allow building owners or managers to designate "third parties" access to their energy data.
Audit data	Audit data will include building location, type, floor area, and, typically, monthly or annual energy consumption values by type. More detailed information on the construction and equipment characteristics can also be identified from audit data.
Architectural or engineering drawings	Can potentially provide enough information and data to define basic, and possibly very detailed, building information

Source: C40 Cities 2018.

1.2 Understand Benefits and Potential Barriers

The second component of the assessment stage of establishing a voluntary EBEE targets and improvement program in a city is to evaluate the potential benefits and barriers. Questions cities will want to answer as part of a comprehensive benefits and barriers assessment include the following:

- What information exists on the benefits of city-level voluntary EBEE targets and improvement programs (e.g., case studies, reports, analyses)?
- What additional information is needed to assess the benefits, and how could this be obtained?
- What barriers may be faced in development and implementation of voluntary EBEE targets and improvement program?
- How can these barriers be overcome?
- Can cost-benefit analyses associated with an EBEE targets and improvement program be conducted?

In the case of a voluntary EBEE targets and improvement program, municipalities that have deployed voluntary EBEE targets and improvement programs have earned reputational benefits; realized environmental benefits, such as reduced building gross energy usage and GHG emissions; and achieved economic gains, such as creating new jobs and increased business for ESCOs (Navigant et al., 2015; Burr et al. 2013). Yet despite the numerous benefits, cities often face a number of barriers when establishing and implementing a voluntary EBEE targets and improvement program (Becque et al. 2016). These will depend on the unique circumstances of the city, but typical barriers can often be categorized as market, financial, technical, awareness, and institutional

To help cities get started with a benefits and barriers assessment, Table 5 below describes some of the typical barriers faced by cities in establishing EBEE targets and improvement programs, and their potential solutions. It is recommended that cities use the barriers identified in Table 5 below and then engage stakeholders in the city (e.g., government, civil society, utilities, building owners, manages, and occupants,

technical and financial building service providers) to see which of the barriers identified below are relevant for their city (or what additional barriers may apply) (Becque et al. 2016). Stakeholder engagement could include expert interviews (in-person and telephone), stakeholder workshops, and/or online surveys to collect input on EBEE barriers from each of the identified stakeholder groups. This will help cities identify which barriers and solutions to focus on in order to design and implement a successful EBEE targets and improvement program.

Table 5. Typical Barriers to EBEE Targets and Improvement Programs

Category	**Typical Barriers**	**Potential Solutions**
Market	Split incentives: economic benefits of energy savings do not accrue to those who invest in energy efficiency Multiple industries: construction, efficiency, energy industries are involved, posing a multi-sectoral challenge. Low energy tariffs discourage energy efficiency investments.	Consider "green leases" which overcome the split incentive by allowing building owners to recoup the cost of EBEE investments and the tenant to benefit from lower utility bills. Utilize codes and standards to encourage the buildings industry (designers, developers, owners, managers, and service providers) to design, build, and operate buildings at significantly reduced energy usage levels. See the Building Efficiency Accelerator (BEA) *Codes Playbook*. Increase access to data, studies, and information on the economic and non-economic benefits of EBEE which can help to accurately evaluate the true value of energy efficiency.
Financial	High transaction costs, small deal size, long payback period, and high credit risk. Few structures for institutional investors to assess credit worthiness of project owners efficiently and at scale. For building owners, high upfront costs and dispersed operational benefits. For building owners, a lack of external finance. Energy efficiency investments are perceived as technically complicated and financially risky.	Provide government incentives to help "buy down" the high first cost of more efficient technology and equipment for building owners. Allow longer payback time for energy efficiency improvements through innovative payback strategies, such as allowing an investment to be repaid on the utility bill (by the tenant) or on a tax bill (by the owner). Communicate with building owners the link between energy savings, net operating income (NOI), and building asset value (e.g., each $1 saved in energy increases asset value by approximately $15 at a 6.5% capitalization rate, so a building that saves $100,000 in energy costs, increases its asset value by $1.5 million).[5] Develop or make available financial calculators that quantify the payback period, net present value (NPV), and return on investment (ROI) of energy efficiency upgrades.[6]
Motivational	Owner reluctance: energy use is a small proportion of building operating costs, complicated loan and permit procedures, and don't want to interrupt building operations.	Offer public recognition/awards (e.g., ENERGY STAR® plaque and Annual Awards Event). Avoid "name and shame" policies and programs that penalize poor energy performance as these are not effective motivators. Communicate with building owners the link between energy savings, NOI, and building asset value. [7]

[5] Asset value = net operating income / capitalization rate

[6] Berkeley Lab's BETTER tool can help to quantify the cost savings potential associated with building energy efficiency improvements.

[7] Asset value = Net operating income / capitalization rate

	Reluctance to share energy performance data for "fear of looking bad" or "sharing company secrets." Lack of public recognition or awards for top energy performance.	
Technical	Insufficient workforce capacity to identify, develop, implement, and maintain energy efficiency investments. Few tools in the market to establish verifiable energy performance baselines and to monitor savings from energy efficiency retrofits. Lack of publicly disclosed data to support retrofit identification and monitoring and verification. Lack of affordable energy-efficient technologies.	Provide education, training, tools and technical assistance through workforce development programs. Use the BETTER tool to establish a verifiable energy performance baseline for a building.[8] Visit the U.S. Department of Energy (DOE) Better Buildings website for information on energy efficiency solutions: technology information suites, case studies, implementation models, showcase projects, etc.[9] Encourage buildings to implement simple, no-cost and low-cost operations and maintenance (O&M) improvements *first* that can save 10-20% annually in energy costs before investing in new equipment.[10] Use BEA's *Operations Checklist* to track the completion of BEA's simple O&M measures for your building that can save significant energy annually. Consider procuring energy services once all the low-hanging fruit has been picked.
Awareness	Lack of data and information about the energy performance of buildings. Lack of information on energy performance of equipment and technologies (for both investors and building owners). Energy information may not be provided or analyzed by end-users, energy providers, or other implementing agencies.	Review the list of typical data sources in Table 1 of this Playbook. Contact BEA for a data collection template and/or to attend a BEA training on data collection. Start by collecting the minimum data points identified in Assess to develop and measure progress toward targets for your city. Access the C40 Cities Manual: *Using Data for Policy*. Visit the U.S. Department of Energy Better Buildings website for information on energy efficiency solutions: technology information suites, case studies, implementation models, showcase projects, etc.[11]
Institutional	Limited capacity to design and to implement energy efficiency policies, programs, building codes, and standards. Limited inter-departmental and inter-agency coordination to ensure policy coherence (at different levels of government)	Use the BEA *Codes, Targets, and Retrofits Playbooks* as a first step in building capacity in a city to improve building energy efficiency. See Chapter 2, *Assess C: Changning District Case Study, Activity 1: Identify Stakeholders and Assign Roles* for diagrams showing how various institutions coordinated and worked together to implement a voluntary EBEE targets and improvement program. Target incentives at building owners/managers (demand side) through special loan programs and rebates.

[8] Contact the BEA or visit https://better.lbl.gov/

[9] https://betterbuildingssolutioncenter.energy.gov/

[10] Contact the BEA to attend a training on how to implement more than 30 no-cost/low-cost O&M measures (e.g., how to control equipment operating schedules, how to correcting over-lit conditions; how to improve heating, ventilating, and air-conditioning (HVAC) performance through coil/filter cleaning, static temperature reset, etc.).

[11] https://betterbuildingssolutioncenter.energy.gov/

	Regulators pay limited attention to demand-side measures. Traditionally, policy packages rely on supply-side. Energy providers/retailers are compensated for selling energy, but receive no financial income from promoting energy efficiency with their customers. Government and the private sector rarely collaborate in public-private partnerships to tackle energy efficiency.	Government collaboration with the private sector on implementation of energy efficiency retrofits in public buildings can lead by example. Develop policies that encourage ESCOs to implement energy performance contracts (EPC) and bring more energy services to the market.

Source: Becque et al. 2016

Case Study: Understanding Benefits and Potential Barriers

Coinciding with an assessment of existing targets, policies and programs, and available data, Changning District, Shanghai government invited the World Bank and an international consulting firm to partner with the Shanghai Energy Conservation Supervision Center (SECSC) to develop a CO_2 abatement cost curve[12] to set a low-carbon target and identify priority mitigation options for the District.

The Hongqiao Economic and Technology Demonstration Zone (ETDZ) was selected for the abatement curve study. With a population of 80,000, its gross domestic product (GDP) accounted for 28.5% of the total of Changning District, 93% of which was contributed by the service sector, and was therefore considered representative in terms of typical abatement options in Changning District.

12 For the details on how Changning District used the World Bank's cost curve tool, please see:
World Bank. 2013. *Applying Abatement Cost Curve Methodology for Low-Carbon Strategy in Changning District, Shanghai*. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/16710.

A survey of 100 buildings (6 offices, 13 hotels, 7 shopping centers, 46 commercial buildings, 9 mix-use buildings, and 19 others) in the Hongqiao ETDZ was undertaken; three alternative abatement scenarios (*Frozen Technology Scenario; Baseline Scenario to Meet the National Government's Target; and Stretch Scenario beyond National Government's Target*) were developed; and a CO_2 abatement cost curve showing abatement potentials, costs, and ease of implementation for various mitigation options was developed (shown in Figure 3). The study was the first of its kind in China and allowed the District government to make an informed decision about medium-term targets of CO_2 abatement and identify priority actions and investments to meet them (World Bank 2013).

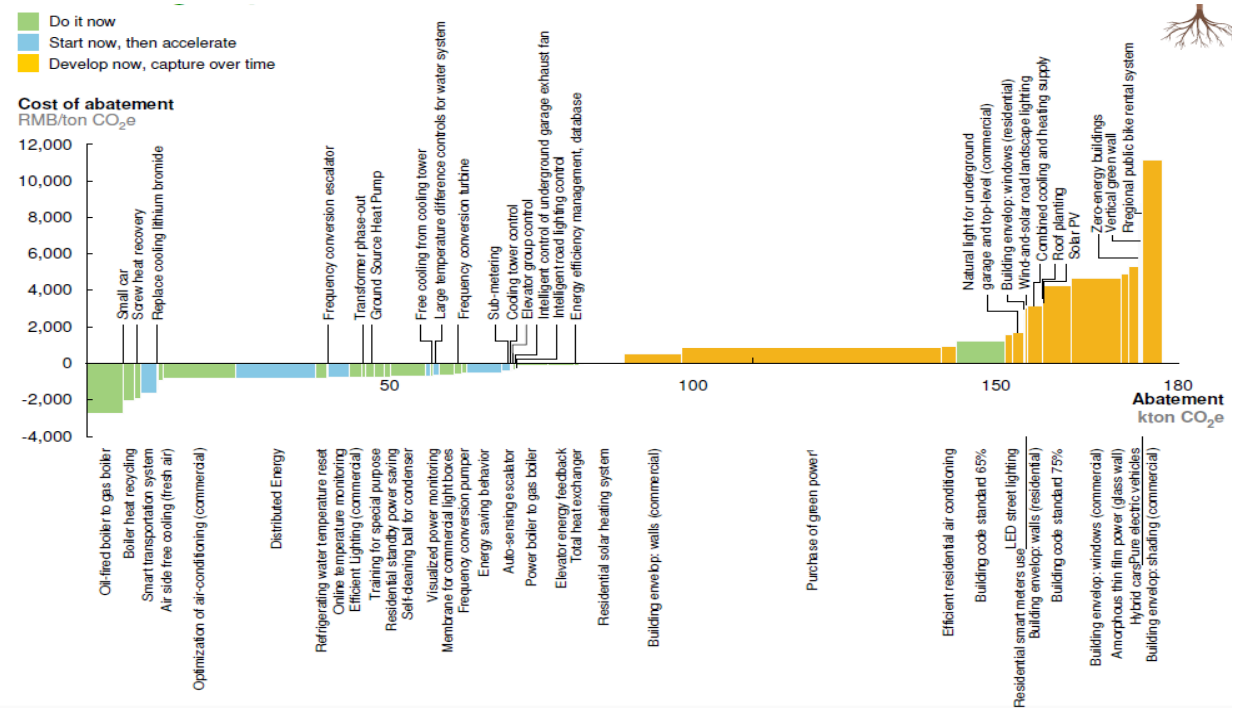

Figure 3. Abatement Cost Curve with Ease of Implementation in Hongqiao Area, Changning District in 2015. Source: World Bank 2013.

Based on the abatement cost curve study, Changning District determined that to achieve the low-carbon objective in the *Stretch Scenario.* It would need to reduce energy consumption of the 100 buildings surveyed in Hongqiao demonstration area by 18%, or equivalent to an energy saving of 33,000 tons of coal equivalent (TCE) (SECSC 2013). It also determined that EBEE improvement was the single largest emission-reduction opportunity in the district and commercial building retrofits offered by far the largest CO_2 emission reduction opportunity in Changning District, compared to government and residential buildings (SECSC 2013; World Bank 2019).

Based on the abatement cost curve analysis, Changning District determined that retrofitting commercial buildings, as part of an overall voluntary EBEE targets and improvement program, offered by far the largest energy conservation opportunity in Changning District. They also noted numerous barriers to establishing a voluntary EBEE targets and improvement program that would involve retrofits including the following (SABR 2019):

- *Lack of Mandatory Retrofit Policy*. The principal barrier to commercial building retrofit is that owners are reluctant to invest in EE measures without a mandatory policy, because: (a) energy costs are a small proportion of building operating costs and are usually passed on to the tenants; (b) building retrofit investments often have a long payback period; (c) owners do not want to disrupt operation of the buildings for retrofit; and (d) complicated procedures associated with loan applications, permits, etc.
- Split Incentives. Building EE projects usually face split incentives: the investors in retrofit measures and the beneficiaries of energy savings are usually different parties. Beneficiaries do not pay the costs and payers are not beneficiaries in the majority of cases where the owner does not occupy the building. It is critical to understand the intricate relationships among government entities, building owners, property management companies, renters, utilities (including heat supply companies), and ESCOs, so that policies and financing mechanisms will be targeted to the right groups.
- Lack of Financial Incentive Mechanisms and Business Models. Financial institutions are usually hesitant to finance building EE retrofits due to: (a) the small size of the deal (between US$150,000 and US$500,000); (b) long payback period (often more than 10 years), while most private sector investors are not willing to make an investment beyond 3-5 years payback period; (c) high transaction costs, high credit risks of ESCOs, which oftentimes have a weak balance sheet, (d) and high perceived technical risks that the anticipated energy savings from the retrofit may not be realized. Further, there are few successful business models that make EE retrofit projects (which are typically small and dispersed) attractive to investors by reducing these performance risks (e.g., unrealized savings) and minimizing transaction costs for financing (SECSC 2013).

1.3 Identify Stakeholders, Tools and Resources Needed

The third component of the assessment stage of establishing a voluntary EBEE targets and improvement program in a city is to determine: what specific institutions and individuals need to be involved in the design implementation of the program; what roles should these institutions and individuals take (e.g., leadership in design of targets, technical and strategic advisory for program implementation); what resources/tools these institutions and individuals need to fulfill their roles; and how to ensure these institutions and individuals have access to these tools/resources. Key questions cities will want to ask in the final assessment phase include the following:

- What institutions in the city have responsibilities and/or expertise in EBEE (e.g., government, academic, research, private sector, non-profit, consultants)?13
- How are EBEE responsibilities currently divided across relevant institutions?
- Which institution(s) should be assigned leadership and/or support roles in establishing the EBEE targets, designing the improvement program, implementing the improvement program, and/or advising technically and/or strategically?
- Do these institutions have all of the tools and resources required (e.g., financial, equipment, skills) to fulfill their roles? If not, where and how could the necessary resources be procured?

[13] If existing institutions do not have responsibilities and/or expertise in EBEE, the city may need to establish a new institution. The Changning District Case Study below provides an example of how a city established a new institution which coordinated and integrated the strengths of different stakeholders to support the district's low carbon transition.

To help cities get started, typical stakeholders in an EBEE targets and improvement program are shown in Table 6 below:

Table 6. Typical Stakeholders Involved in EBEE Targets and Improvement Programs

Stakeholder Group	**Examples**
Government Stakeholders	National, provincial, and/or local government agencies with authority/responsibilities for EBEE improvement (e.g., construction agency, energy agency)
Building Stakeholders	Building owners, managers, and tenants.
Technical Service Providers	Designers, developers, builders, equipment manufacturers and suppliers, ESCO, engineers, auditors, equipment vendors, international and domestic consultants.
Financial Service Providers	Central bank, local banks, multilateral development banks, insurance companies, etc.
Civil Society	Non-government organizations (NGO)
Utilities	Energy and water utilities

Source: Becque et al. 2016.

Tools and resources these institutions and individuals need to fulfill their roles will vary but may include building energy modeling tools, retrofit analytical tools, building energy performance benchmarking tools, building energy information systems, or marginal abatement cost curve tools. Table 6 below describes tool features and some free tools to help cities get started. Resources may include case studies, technology or policy guidebooks, or access to relevant training. Places to obtain free resources to facilitate city EBEE Targets and Improvement programs can be found in Table 7 below.

Table 7. Tools to Facilitate EBEE Targets and Improvement Programs

Categories	**Features**	**Tools**
Building Energy Modeling (BEM) Tools	Provide simulation of building energy use in order to design more energy-efficient buildings.	EnergyPlus® OpenStudio® eQuest® DOE-2 EDGE
Retrofit Analytical Tools	Identify equipment or operational improvement opportunities. Quantify energy and cost savings, or investment cost, associated with upgrades (Lee et al. 2014)	BETTER Energy Asset Score COMBAT Building Performance Database (BPD)
Building Energy Performance Benchmarking Tools	Compare a building's operational energy performance, or the performance of a building's systems and equipment, to other similar buildings in the marketplace.	ENERGY STAR® PortfolioManager® BETTER Energy Asset Score

Building Energy Information System (EIS)	"Used to store, analyze, and display building energy data. EIS often include analysis methods such as baselining, benchmarking, utility and carbon tracking, load profiling, and energy anomaly detection" (Smart Energy Analytics Campaign 2020)	Better Buildings® Energy Management Information Systems (EMIS) Solutions Center
Marginal Abatement Cost (MAC) Curve Tool	Present and compare economic costs of various CO_2 emissions abatement options.	World Bank Energy Sector Management Assistance Program (ESMAP) MAC Tool

Table 8. On-line Resource Centers to Facilitate EBEE Targets and Improvement Programs

On-Line Resource Centers	**Description**
U.S. Better Buildings Solutions Center	Provides toolkits on energy data management, financing, lighting, renewables, and space conditioning; showcase projects; technology information suites; and access to events and webinars.
U.S. ENERGY STAR® Commercial Buildings Program	Provides a building energy benchmarking tool, a building energy management plan framework, case studies, building upgrade manuals, etc.
Berkeley Lab Building Technologies and Urban Systems	Provides information and tools related to windows and daylighting, lighting and electronics, modeling and simulation, indoor air quality, energy analytics, the grid and demand response, cool roofs and walls, and energy and financing.
C40 Cities Climate Leadership Group	Provides access to networks, events, programs, and research for cities to assist them in reducing energy consumption in buildings.
Building Efficiency Accelerator	Provides cities with reports, case studies, databases, and tools for cities related to energy codes, incentives, finance, procurement, retrofits, and tracking progress.
Institute for Market Transformation	Provides case studies, fact sheets, guidebooks, reports, videos, and webinars to help cities in the areas of energy codes, finance, green leases, data, etc.
BETTER	Provides links to technical resources on how to implement energy efficiency improvement measures ranging from operational to equipment retrofits.

Case Study: Identifying Stakeholders and Assigning Roles

Changning District's first step in this stage was to identify all stakeholders relevant for designing and implementing a voluntary EBEE targets and improvement program. Stakeholders Changning District identified are as follows:

- Municipal government and sector government (e.g. in charge of schools and hospitals)
- Owners
- Operation management team/property management companies;
- Retrofit developers/ESCOs
- Financial institutions (e.g. banks)

- Renters/government service occupants
- Government agencies in charge of retrofit (Mao 2019)

Changning District's second step at this stage was to set up a new institution under the Shanghai Changning District Development and Reform Commission – the Shanghai Changning District Urban Renewal and Low Carbon Project Management Center (URLCPMC).[14] The purpose of the center was to coordinate and integrate the strengths of different stakeholders like financial institutions, universities, research institutions, and ESCOs, and to take charge of the low-carbon transition of the district, as illustrated in Figure 4 below (SABR 2019). Establishing and implementing the EBEE targets and improvement program was identified as one of the main tasks of the URLCPMC. SECSC and Shanghai Changning District Government also participated in and advised work related to EBEE targets in Changning District. In fact, Shanghai municipal government and Changning district government payed lots of attention to the EBEE retrofitting project. Government officials set up a task force to master the progress, which providing powerful leadership guarantee for the implementation (Mao 2019).

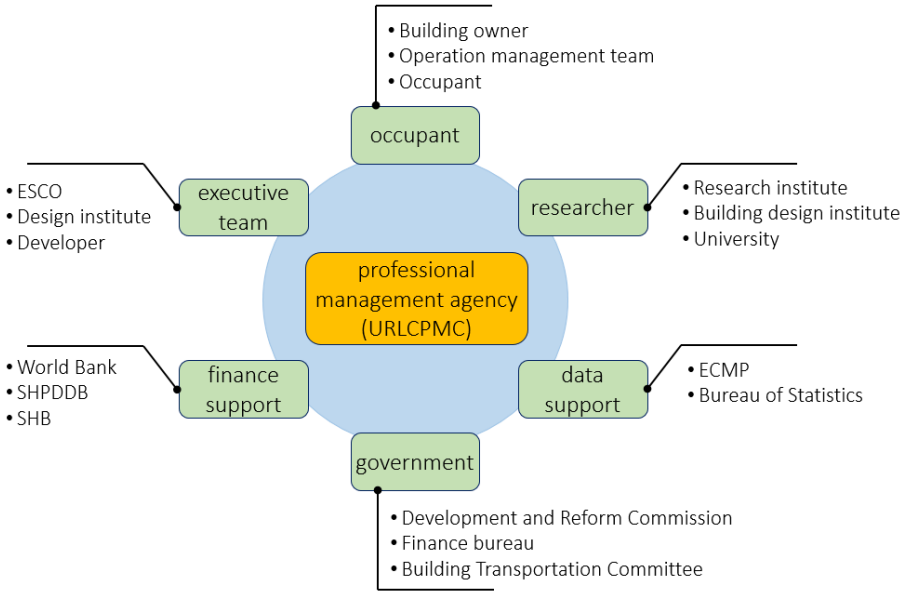

Figure 4. How stakeholders are integrated by URLCPMC in Changning District. Source: SABR 2019, 17.

Changning District then established an organizational structure to support an overall EBEE targets and improvement program involving government departments, financial institutions, and market subjects, as shown in Figure 5 below (SABR 2019, 4).

[14] For cities, they always need to assign an existing institution or set up a new one at the beginning of implementing an ECBEE program. The institution will lead and manage the program from the first beginning to the end.

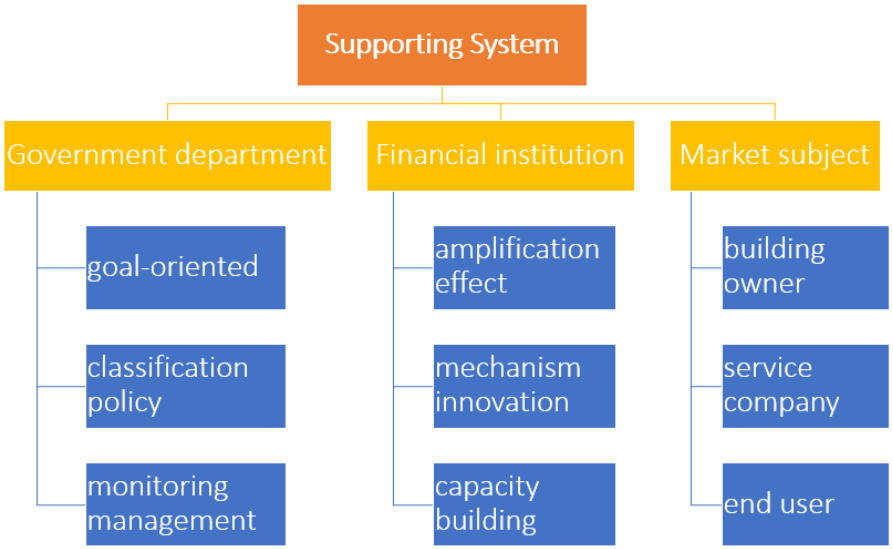

Figure 5. Supporting system of EBEE program in Changning District. Source: SABR 2019, 4.

In its process to design and implement an EBEE targets and improvement program, Changning District also conducted extensive consultations with key stakeholders, including: interviews, seminars, and workshops with building owners, property management companies, tenants, ESCOs, international and national experts, financial institutions, as well as related operators and decision makers (SECSC 2013). Some of the tools and resources identified and utilized by Changning District, Shanghai, can be found in Chapter 2, Assess C: Changning District Case Study, Activity 2: Identify Tools and Resources.

II. DEVELOP

2.1 Define the Scope of the Policy or Measure

Once the assessment phase is completed, and existing resources and information have been collected; the potential benefits and barriers have been evaluated; and stakeholders, tools, and resources have been identified, a city can begin to develop the voluntary EBEE targets and improvement program. The development stage includes four components: defining the scope of EBEE targets and improvement program; developing a locally-appropriate program; adopting the program; and developing an implementation plan. Questions municipalities will want to answer initially to help define the scope of the EBEE targets and improvement program are as follows:

- What type of EBEE targets and improvement program will be established? (e.g., energy-use intensity (EUI)-based target, percentage better than baseline target, better than code target, energy consumption quota, cap and trade system, information program)?
- How will the EBEE target(s) be established (i.e., what science-based method(s) will be utilized to set the target(s))?
- What are the advantages and disadvantages of various approaches to establishing EBEE target(s)?
- What are the estimated costs and impacts of the EBEE targets and improvement program?
- In which buildings (i.e., space type, size, location) will the EBEE targets and improvement program be implemented?
- What will be the scope of the EBEE targets and improvements program (i.e., will the program include any training, use of benchmarking tools, financing, ESCOs)?
- How will the targets contribute to national and local GHG emissions target(s) and/or energy policy target(s)?

Case Study: Defining the Scope in Changning

As described in "Assess B: Understand Benefits and Potential Barriers," Changning District, utilizing the CO_2 abatement cost curve, determined that to achieve the low-carbon objective in the *Stretch Scenario*, the district would need to reduce current energy consumption in 100 existing building in the Hongqiao ETDZ by 18%, equivalent to 33,000 TCE. With this as the overall goal, Changning District considered two distinct methods for target-setting at the individual building-level (SECSC 2013):

- National Building Codes as the Targets (see details in Chapter 2, Develop A: Define Scope of the Policy of Measure, Activity 1: Select the Type of EBEE Targets and Improvement Program, 1a). Codes as targets are important for cities to consider because they can be easier and more legitimate to enforce.
- Performance-based Benchmarking in Kilowatt-hours per Square Meter (kWh/m2). Under this methodology, four approaches (see details in Chapter 2, Develop A: Define Scope of the Policy of Measure, Activity 1: Select the Type of EBEE Targets and Improvement Program, 1a 2a, 2b, 2c, 2d) were used to rank 100 buildings in Hongqiao ETDZ and determine which building should participate in the EBEE targets and improvement program, and what the individual EBEE targets should be, in order to achieve the overall district-level target of 33,000 TCE. Performance-based benchmarks are important for cities to consider because they are directly

link to overall energy and emissions savings targets, and measurement and verification of savings is straightforward to implement (SECSC 2013, 60).[15]

In addition to the Changning District, Shanghai Case Study, Table 9 shows a selection of EBEE targets and improvement programs which provide examples of the ways in which countries and cities have sought to improve energy efficiency in buildings through voluntary program strategies.

Table 9. Selection of Global EBEE Targets and Improvement Programs

EBEE Targets and Improvement Programs	Description
U.S Better Building Challenge	The Better Building Challenge is a voluntary leadership initiative of the U.S. DOE with the goal of leading businesses, manufacturers, cities, states, universities, and school districts commit to improving the energy efficiency of their portfolio of buildings by at least 20% over 10 years and share their strategies and results.
China Better Buildings Program	China Association of Building Energy Efficiency (CABEE) launched a voluntary program, China Better Buildings, in 2017. The goal is assisting all types of existing commercial buildings across the country to achieve 10-20% energy savings over five to 10 years.
Copenhagen	Municipal buildings represent 6% of Copenhagen's building stock and the city is leading the way on city retrofits by renovating its portfolio. It has set a target to reduce energy consumption in municipal buildings by 40% from 2010 to 2025.
New York City	The Department of Citywide Administrative Services' (DCAS) is responsible for achieving the city government's GHG emissions reduction targets, including a 40% reduction for city-owned buildings by 2025, a 50% reduction by 2030, and a city-wide reduction of 80% by 2050.

2.2 Develop Locally Appropriate Policy, Building on National, Regional, or Global Models

Once a municipality has defined the scope of the policy or measure, the next step is to develop a locally appropriate policy, building on national, regional, or global models. Questions to answer at this stage include the following:

- Will there be any incentives and/or disincentives to motivate buildings to achieve their EBEE targets?
- If so, what types of incentive(s) (e.g., certification, award, subsidies) or disincentives (e.g., higher utility rates, name and shame list)?
- What is the cost-benefit performance of these incentives or disincentives?
- Will there be technical assistance for buildings to achieve their EBEE targets?
- If so, what type(s) of technical assistance (e.g., training, tools, experts)?

[15] For more information, go to Chapter 2, Develop A: Changning District Case Study, Activity 2: Evaluate Various Approaches to Establishing EBEE Targets, Table 6. Summary of Pros and Cons of Target-Setting Approaches.

Case Study: Developing Locally Appropriate Policy, Building on National, Regional, or Global Models in Changning

Changning District, Shanghai evaluated a range of practical and implementable incentives and disincentives to promote stakeholder buy-in of its overall EBEE targets and improvement program (SECSC 2013, 15). A mapping of these measures by stakeholder group in Changning District is presented in Table 10. This is not a comprehensive list, but an illustration of the various options explored by the district. Table 10 shows that different measures are more appropriate for different stakeholders, which makes it critical for the government to consult with all the key stakeholders when designing any incentives and disincentives to facilitate buy-in of policies.

Table 10. Possible Incentives and Disincentives by Stakeholders

Generic Incentives/Disincentives		Stakeholders						
		Owners	Retrofit Developers/ESCOs	Financial Institutions	Renters	Government Agencies in Charge of Retrofit Permits	Municipal Government	Government Service Occupants
Incentives	Grant	X					X	
	Technical Assistance and Education	X	X	X	X	X	X	X
	Green Performance Award	X			X		X	X
	Low Interest Loan/Line of Credit		X	X			X	
	Rebate	X			X		X	X
	Tax Incentive	X	X					
	Permit Process Incentive	X	X			X		
Disincentives	Administrative and Failure to Perform Fines	X					X	
	Higher Utility Rate/Surcharge	X			X			
	Name and Shame List	X					X	

Source: SECSC 2013, 62.

As a result of this analysis, in January 2013, Changning District developed a new policy, the *Management Method of the Special Funds for Low-Carbon Development in Shanghai Changning District* – which could be valid for five years. This policy's subsidies related to building EBEE improvement are described in Table 11 below.

Table 11. Management Method of the Special Funds for Low-Carbon Development in Shanghai Changning District Policy Description

Policy	Description
Existing Building EE Retrofit Projects Subsidy for Demonstration Projects	This provides a subsidy based on energy saved/investment of US$144.93 per TCE (1000 RMB/TCE) saved. If the building performance improved significantly, a subsidy of 25% of the EE retrofit is provided. This provides a subsidy of US$2,898.55/TCE to US$3,623.19/TCE (20,000 RMB/TCE to 25,000 RMB/TCE) per project.
Subsidy for Interrupted Operation from a Retrofit	This subsidizes 30% of the total rental cost loss, if the retrofit takes six months or more. There is a ceiling of US$0.14 million (RMB 1 million) per project.
Subsidies for Fundamental Work to Build the Low-Carbon Demonstration Area	This includes a subsidy to establish a building energy data on-line monitoring system; a subsidy for assessment and evaluation; a subsidy for low-carbon research; and a subsidy of US$144.93 per TCE (RMB 1000 per TCE) for other low carbon projects in the Low-Carbon Demonstration Area.

Source: SECSC 2013, 12-13.

2.3 Adopt Policy

Once a locally appropriate policy has been scoped and developed, the next step is for cities to adopt the policy. Questions municipalities will need to answer include the following:

- What will be the specific EBEE targets by building type?
- What specific policy measures to facilitate the EBEE targets and improvement program will be adopted?

Case Study: Adopting a Policy in Changning

Changning District determined that it would utilize the normalized target-setting methodology (described in Chapter 2, Develop A: Changning District Case Study, Activity 1: Select the Type of EBEE Targets and Improvement Program, 2d Normalized Target-setting Methodology) to both select buildings and establish energy savings targets for those buildings in order to meet the district's overall energy savings goal of 33,000 TCE saved. The selected buildings (type and number) and the total and percentage energy savings targeted for each building in Hongqiao ETDZ is shown in Table 1 below (EFC(a) 2012, 17).

Table 12. 33,000 TCE Energy Saving Breakdown Table

Building Type		Amount	Total Energy Savings (TCE)		Percentage of Energy Savings
Hotel	Five-star	13	1577.9	2876.5	9%
	Four-star		956.0		
	Three-star and below		342.6		
Shopping Mall		7	8410.6		25%
Commercial Office Building		48	10572.2		32%
Government Office Building		6	982.5		3%
Mix-used Commercial Building		7	7284.7		22%
Other		19	2873.4		9%

Total	100	33000	100%

Source: EFC(a) 2012, 17

Changning District decomposed the total energy saving target (the 33,000 TCE) to different ECB types for retrofit in Table 10. The breakdown was based on the identification of each ECB type's retrofit baseline. The process for Changning to perform this work is shown in Figure 6 below (EFC(a) 2012, 15).

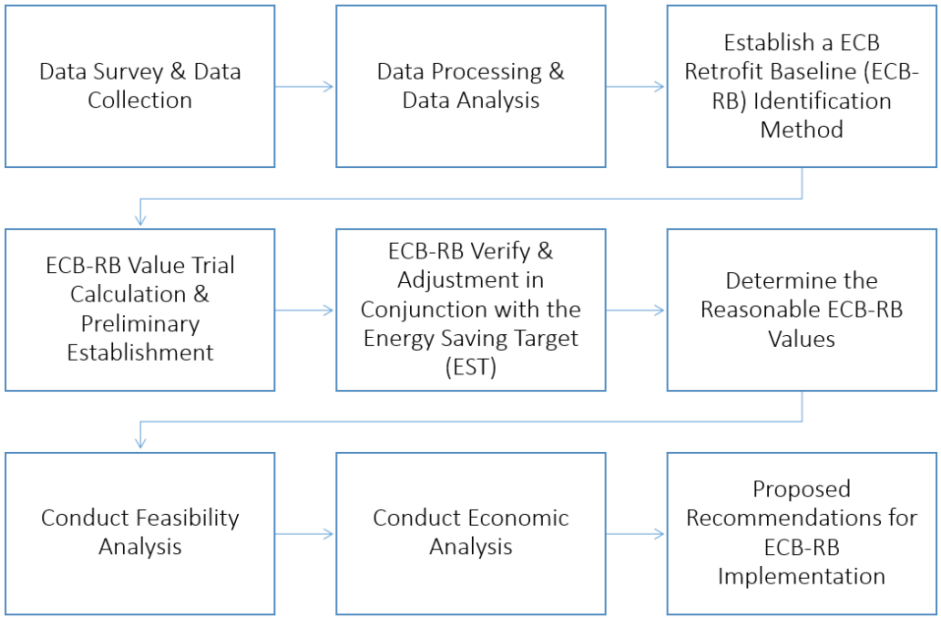

Figure 6. Process to identify the retrofit baseline for different EB types for breakdown the energy saving target. Source: EFC(a) 2012, 15.

2.4 Develop Implementation Plan

After scoping and adopting policies, cities should also develop an implementation plan to ensure policies run smoothly. In this phase, cities will want to answer the following questions:

- What will the implementation plan for the EBEE targets and improvement program contain?
- Will there be a timeframe for buildings to achieve the EBEE targets?
- What tools and resources will be needed (e.g., spreadsheets, project planning software, etc.)?

Case Study: Developing an Implementation Plan and Timeframe in Changning

To achieve its goal to reduce energy consumption in 100 existing building in the Hongqiao ETDZ by 18%, equivalent to 33,000 TCE, Changning District adopted a three-phase implementation plan as follows:

- Phase I – focuses on improving EE in the buildings where actual EUI is higher than the target value. They represent large energy saving potential that can be achieved at lower cost (e.g., operational improvements, lighting retrofits).
- Phase II – focuses on improving EE in buildings where actual EUI is higher than the target value. They represent large energy saving potential that can be achieved at higher cost (e.g., envelop retrofit).

- Phase III – focuses on buildings where actual EUI is higher than the target value, but the actual energy saving potential is small (SECSC 2013, 62).

Changning District also constructed a time series plan for the EBEE targets and improvement program based on the World Bank project duration of five years (5 years) and marketing cycle theory which is illustrated in Figure 7 below (EFC(b) 2012, 22).[16]

- Single EBEE cycle = marketing cycle + theoretical construction period.
- All of the 100 EBEE projects needed to be completed within the World Bank's five-year (60-month) project.
- With the Building Energy Efficiency Project Implementation Plan – Computer Aided Tool (PIP-CAT), Figure 7 shows the decision and implementation timeframe for implementing EE improvements in each of the 100 buildings in the Hongqiao ETDZ under the dual conditions of incentives and disincentives in Changning District.

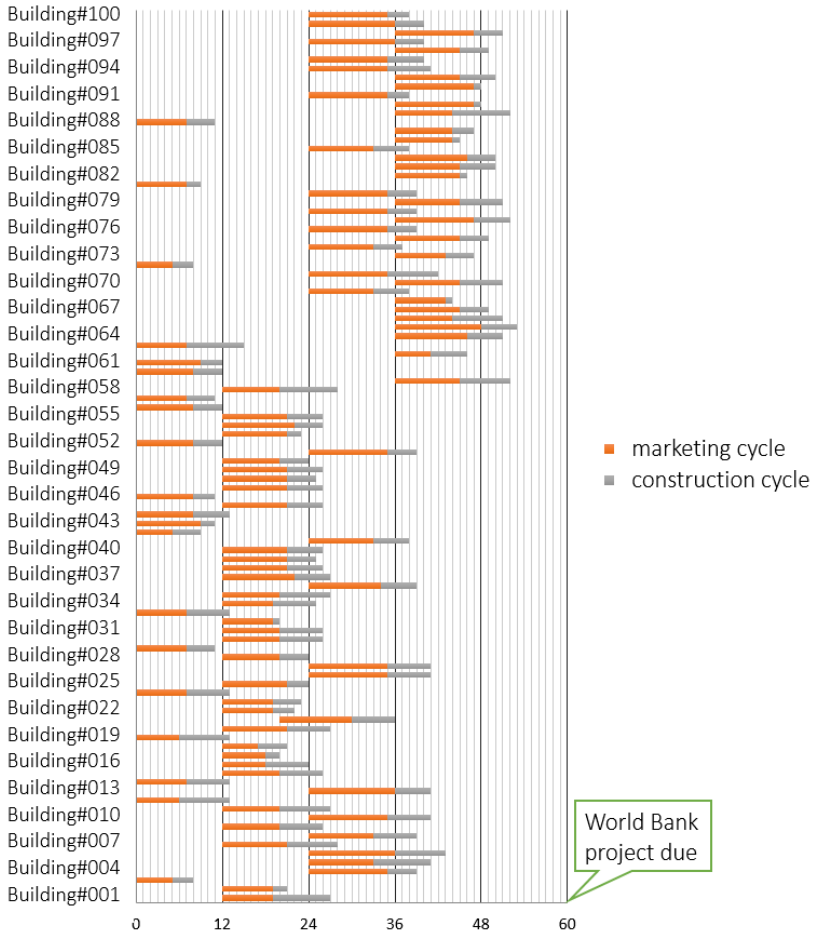

Figure 7. EBEE improvement decision and implementation timeframes for 100 buildings under the dual conditions of incentives and constraint. Source: EFC(b) 2012, 22.

[16] "Marketing cycle" refers to the time from the start of negotiations to the signing of the contract.

III. IMPLEMENT

3.1 Implement Energy Saving Actions

After completing the assessment and development stages, which include collection of existing resources and information; understanding benefits and barriers; aggregating stakeholders, tools, and resources; scoping and adopting a program; and developing an appropriate implementation plan, cities are then ready to implement EBEE targets and improvement programs. Questions municipalities will want to answer at this stage include the following:

- What procedures in a plan are needed to implement the voluntary EBEE targets program?
- How will the stakeholders participate in and interact with each other in the implementation process?

Case Study: Implementing Energy Saving Actions

In Changning District, the URLCPMC implemented a detailed project management process, shown in Figure 8, to provide comprehensive support to the building owners participating in the EBEE Targets and Improvement Program (SABR 2019, 19). Within the project management processes, main stakeholders were all included with a clear role. Each procedure might involve more than one party, and each party might participate in different procedures.

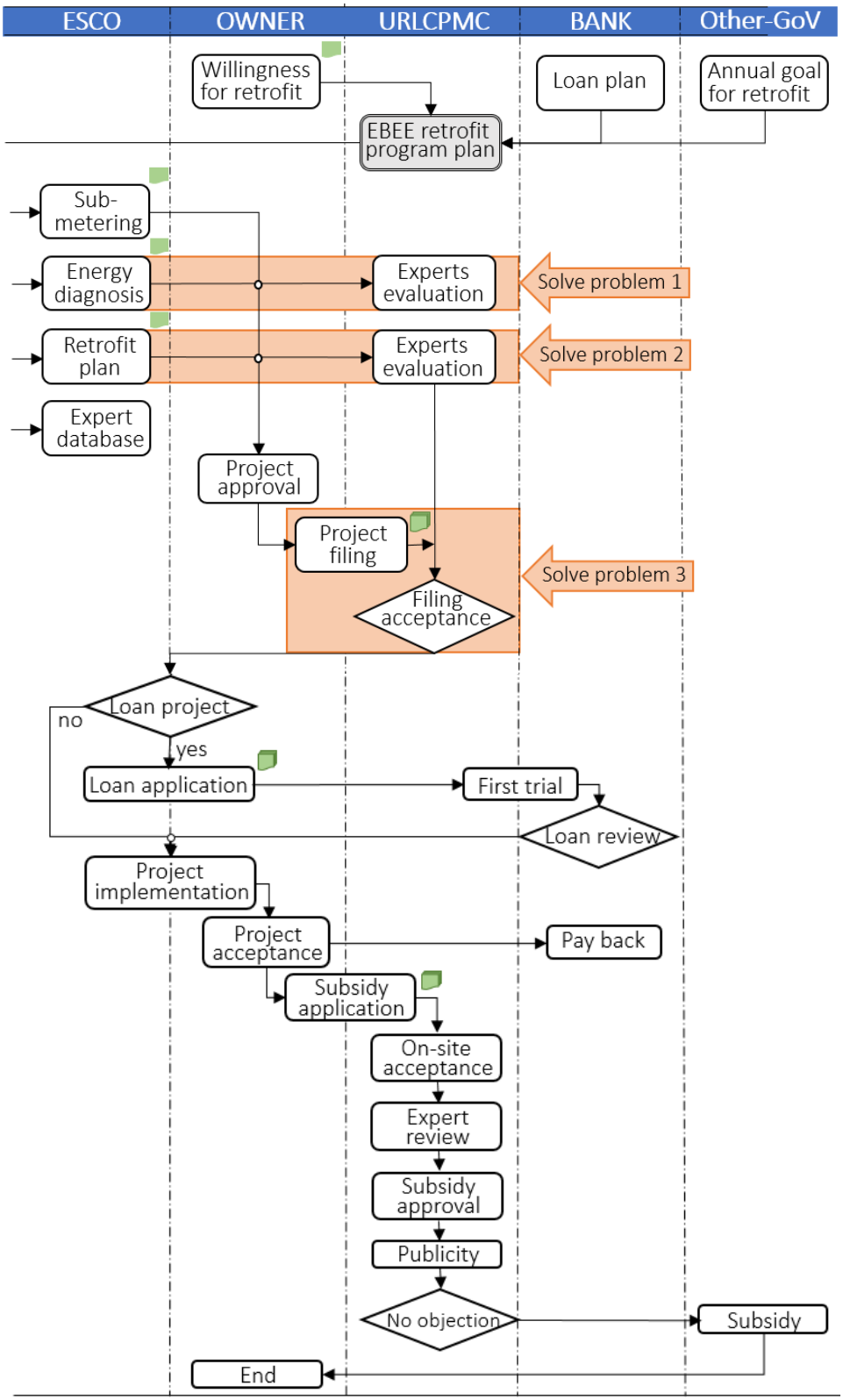

Figure 8. EBEE Project Management Process Implemented by Professional Management Agency – URLCPMC. Source: SABR 2019, 19.

3.2 Monitor Progress and Make Adjustments, Taking Immediate Action to Resolve Problems that Arise

After cities have begun to implement EBEE Targets and Improvement Programs, it is important to monitor progress, identify problems, and make adjustments to ensure overall program success. Questions municipalities will want to answer include the following:

- How will the impact of the EBEE targets and improvement program be measured and evaluated (e.g., what key performance indicators (KPI) will be measured and evaluated, how so, how often)?
- What outcome indicators will be used to evaluate the EBEE targets and improvement program?
- How will progress towards EBEE targets be measured and verified?
- Who will participate in measurement and verification (M&V)?
- What is the level of participation in the voluntary EBEE targets and improvement program?
- Identify problem areas and take corrective actions.

Case Study: Monitoring Progress and Building Feedback Mechanisms to Resolve Problems

Changning District selected a few key performance indicators (KPI) to measure and evaluate the progress of its EBEE targets and improvement program. The KPIs include the following:

- Number of buildings implemented retrofit
- Total floor area implemented retrofit
- Energy savings realized through retrofit
- Energy savings rate realized through retrofit
- Total CO2 emission reduction through retrofit
- Total subsidies approved to the retrofit projects
- Percentage of the target achieved

Within the KPIs above, URLCPMC of Changning District implemented the EBEE program and reviewed the progress periodically. Given that the EBEE improvement projects were easily influenced by a lot of exterior factors which were out of anyone's control, it was hard to conduct an annual progress review. Thus, Changning District adopted a flexible progress monitoring method, which combined the EBEE program's progress assessment with the World Bank project's requirement of a phased assessment, or when either Shanghai municipalities or Changning district-level Government required (EFC(a) 2012).

The URLCPMC of Changning District also paid great attention to the effectiveness of relevant technologies and policy effects in its EBEE targets and improvement program. They continually optimized and improved the technology solution and policy system on the basis of feedback mechanisms so that technologies and policies could better meet the actual needs of the market (SABR 2019, 20). As shown in Figure 9, the URLCPMC of Changning District set up a technical effect feedback mechanism to identify excellent energy-saving technologies, research new technologies, and guide owners and third parties to adopt appropriate technologies.

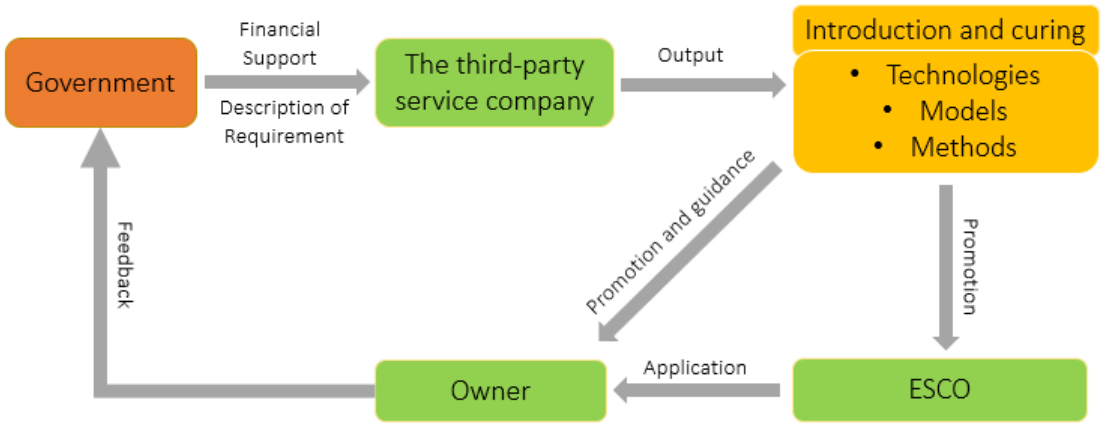

Figure 9. Technical effect feedback mechanism in Changning District. *Source:* SABR 2019, 20.

The URLCPMC of Changning District also paid attention to the policy effects. It evaluated the implementation effect of the EBEE retrofit policies issued by the government, provided policy opinions and suggestions, and influenced the optimization and improvement of government policies (Figure 10) (SABR 2019).

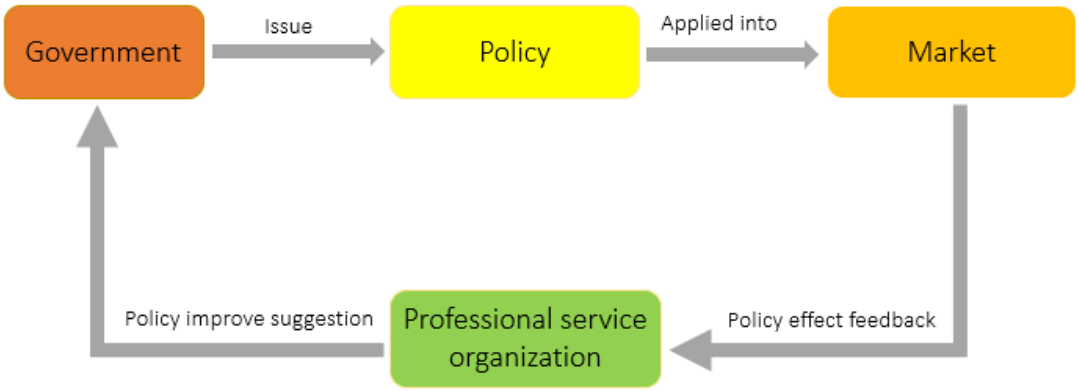

Figure 10. Policy effect feedback mechanism in Changning District. *Source:* SABR 2019, 20.

3.3 Showcase Results to Stakeholders and the Public

Another important reason to monitor progress is to be able to showcase and communicate results to key stakeholders. Results should be quantified in terms that will resonate with the specific audience being targeted. For instance, environmental gains may resonate well with the government and citizens. The business community may care more about energy cost savings and new job created. Questions municipalities will want to answer include the following:

- What level of energy and/or GHG emissions reductions have been achieved?
- What other benefits from the voluntary energy efficiency target program have been realized (e.g., increased market for energy efficiency services, increased building comfort)?
- To what extent have the targets helped support energy and GHG emissions reductions in buildings?

- How can participants and outstanding performers be recognized (e.g., annual awards, certification, website)?
- What audiences should be notified of the success (e.g., international, national, local leadership; funders; citizens, etc.)?

Case Study: Showcasing Results to Stakeholders and the Public

Changning District implemented the EBEE improvement projects in phases as outlined in the implementation plan. During the implementation of the program, Changning District took comprehensive measures to promote the EBEE targets and improvement program. In the end, significant achievements were realized as follows (SABR 2019):

- A total of 45 existing buildings completed, with a total floor area of 2.87 million m2, completed energy efficiency upgrades.
- Total energy savings were equivalent to 31,233 tons of standard coal (TSC).17
- Emissions of 63,285 tons of CO_2 was avoided (SABR 2019).

Some examples of how Changning District communicated its success to stakeholders are shown in Figure 11 below:

(a) Promotion Video (b) Brochure (c) Meetings (d) Conferences

Figure 11. Policy effect feedback mechanism in Changning District. *Source:* SABR 2019, 21.

The city Copenhagen, Denmark also provides an excellent example of how results from a pilot project can be quantified and communicated to stakeholders, shown in Figure 12 below. The municipality conducted an investigation into deep energy retrofit of five schools, including evaluating improvements to the building envelope; glazing; heating, ventilating, and air conditioning (HVAC); and lighting. The potential achievements of the five schools were calculated in both environmental and economic terms, including GHG reductions, job creation, NPV, payback period, reduced energy costs, and increased productivity. The city also calculated the potential benefits of scaling up from retrofits of five schools to 40 schools, increasing the potency of their messaging (C40 Cities et al. 2020).

[17] The energy saving here is calculated with energy savings in each building's EE plan, not an actual measured value.

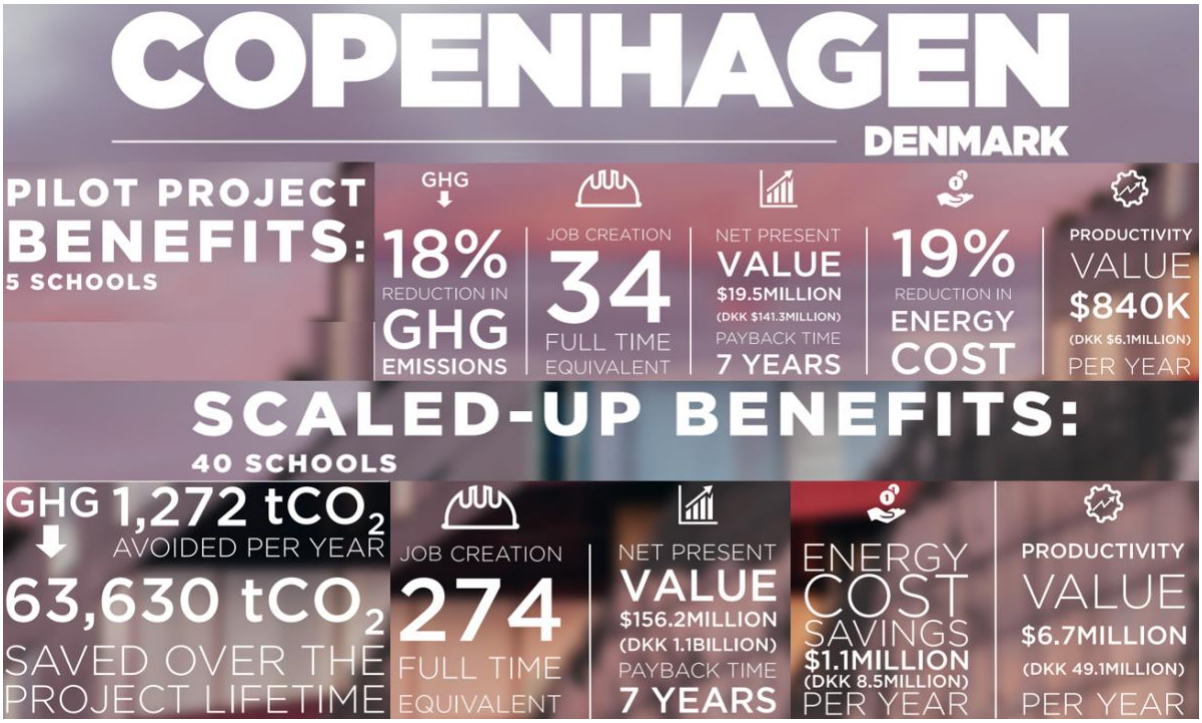

Figure 12. Copenhagen Denmark EBEE Pilot Project Communications. *Source:* C40 Cities et al. 2020.

IV. IMPROVE

A critical last phase of an EBEE Targets and Improvement Program is to improve performance. There are typically two components to this phase: review and evaluate implementation, impacts, and potential; and analyze evaluate results and assess next steps.

4.1 Review and Evaluate Implementation, Impacts, and Potential

Cities will want to start their improvement process with the following questions:

- What is the level of participation in the EBEE targets and improvement program?
- What is the energy/GHG impact from the EBEE targets and improvement program?
- How effective have the supporting tools/resources been?
- How effective have the incentives been?
- Has the institutional set-up been effective?
- What other benefits from the voluntary EBEE targets have been realized?
- What is the scale-up potential for the program (i.e., how can more buildings or savings be achieved)?
- How can these benefits be scaled?

Case Study: Reviewing and Evaluating Implementation, Impacts, and Potential

As shown in Figure 13 in section "Assess B: Case Study on Understanding Benefits and Potential Barriers," Changning District developed a CO_2 abatement cost curve showing abatement potentials, costs, and ease of implementation for various CO_2 abatement options, at the very beginning of the program. The cost curve allowed the Changning District government to make an informed decision about targets and to identify priority actions – such as improving EBEE (World Bank 2013). As the EBEE targets and improvement program progressed, and more and more local data became available (including building types, technologies, costs and energy savings, payback period, etc.), Changning District continually updated its cost curves to include more accurate data to provide better guidance to EBEE projects in the area, and also to provide valuable references for other cities in China and worldwide (Figure 13) (SABR 2019).

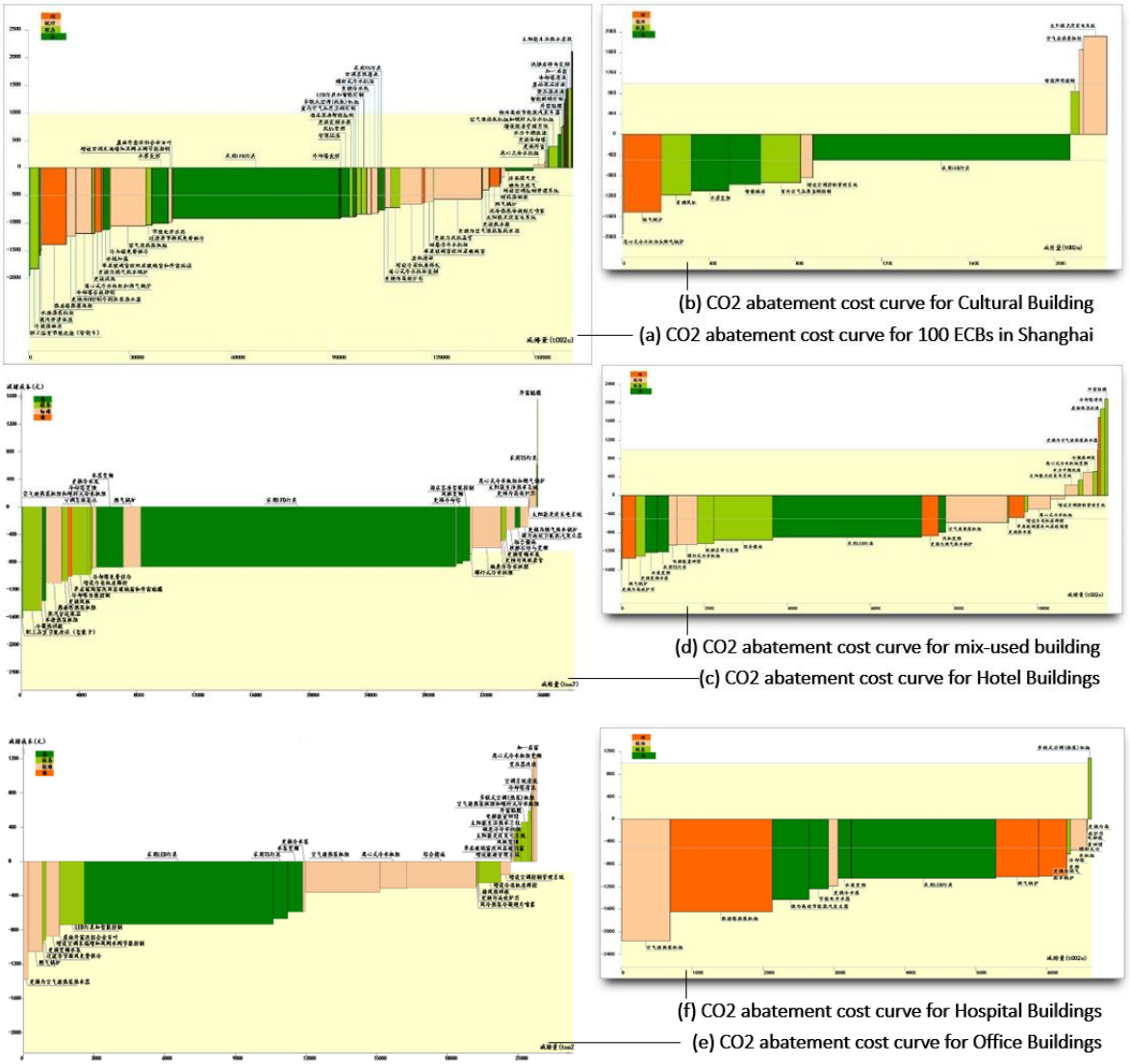

Figure 13. A set of updated CO_2 abatement curves for Shanghai and Changning. *Source:* SABR 2019, 48

Besides the cost curves, Changning District and Shanghai also analyzed financial internal rate of return (FIRR) of different technologies adopted by upgraded buildings by type. The 100 upgraded buildings in Changning achieved a high average energy saving rate at 22.19%, and the average FIRR was up to 20.48% (SABR 2019). These metrics provide valuable benchmarks for cities globally as to the potential savings for EBEE targets and improvement programs.

4.2 Analyze Evaluation Results and Assess Next Steps

In the final step of the improve stage, cities should analyze results of their evaluation and determine appropriate next steps. Questions municipalities will want to answer include the following:

- What has and hasn't worked well in the voluntary energy efficiency targets program?
- What is necessary to improve the targets program?
- Is it feasible to increase targets and/or apply them to more buildings?

- How can this be achieved, and in what timeframe?
- How can the program implementation and impact assessment become fully integrated and mainstreamed into the city's institutional framework so that the program and impact assessment can be sustained in the long term?

Case Study: Analyzing Evaluation Results and Assess Next Steps

The EBEE targets and improvement program in Changning District not only brought significant energy-saving and emission-reducing benefits, but also introduced a set of internationally advanced project management methods and mechanisms to the district. For next steps, through the use of various energy-saving technologies in the Changning District, a number of additional EBEE improvement projects will be implemented in the district, and transformation modes and mechanisms will further be explored.

Based on the accumulated experiences and data, one of Changning District's partners, the East China Architectural Design Institute (ECADI), developed an EBEE optimization tool for its customers in Shanghai (Figure 14) which can help other districts in Shanghai replicate Changning's success. It integrates five functions including the following:

- Energy consumption status assessment and diagnosis
- EE technology introduction and display
- EE retrofit planning and optimization
- CO2 abatement cost curve
- Case database (Mao 2019)

Figure 14. A set of updated CO_2 abatement cost curves for Shanghai and Changning. *Source:* Mao 2019.

With the availability of such tools, the complexities and difficulties of implementing similar large-scale EBEE targets and improvement programs, or a single EBEE improvement project, can be reduced to a great extent. Scaling up become possible and easier.

CONCLUSION

Through reading Chapter 1 of the *Targets Playbook*, it is hoped that cities and districts globally will understand the environmental, economic, and reputational benefits of EBEE targets and improvement programs as well as the steps that can be taken to develop and implement such a program. Moreover, it is hoped that the excerpts from the Changning District, Shanghai case study, and other case studies from around the world, demonstrate the feasibility of setting targets and improving building energy performance at scale. Finally, the availability of free, public access tools and resources listed throughout Chapter 1, such as BETTER and the MAC Tool, it is hoped that cities can get started right away, without a significant outlay of resources, to develop and implement EBEE targets and improvement programs. In Chapter 2 of the *Targets Playbook*, cities and districts can review, in-depth, the case of Changning District, Shanghai, to see how it successfully designed and implemented an EBEE and improvement program between 2013 and 2018 that helped 45 commercial buildings reduce energy consumption by 25,423,662 kWh (31,233 TSC) and avoid 63,285 tons of CO_2 emissions (SABR 2019).

CHAPTER 2

Case Study: Changning District, Shanghai

About Changning District, Shanghai, China

Shanghai lies on China's eastern coast on an estuary of the Yangtze River. It covers an area of 6,340.5 square kilometers (km^2), has a population of more than 24 million, and belongs to the hot summer and cold winter climate zone (IOSM 2018). Shanghai is China's largest economic center, and in 2017 had an estimated per capita gross domestic product (GDP) of US$18,450, equivalent to that of a medium developed country (World Bank 2013). Given its economic prominence, it is one of four municipalities in China that has a status equivalent to a province and reports directly to the central government (Shanghai Highlights 2019). The city is striving to become a global center for finance, trade, and technology innovation by 2035 (IOSM 2018), while at the same time transitioning to a "low-carbon city" (World Bank 2013).

Changning District, shown in Figure 1, is one of 16 districts in Shanghai and located in the West Downtown area (IOSM 2018). It covers an area of 38.30 km^2 and has a resident population of 693,700 (Shanghai Statistical Yearbook 2018; Sherlock et al. 2018). Changning District is an established district with mostly commercial buildings and few industrial activities (World Bank 2013). Moreover, the district is at the forefront of Shanghai's effort to transition to a "low-carbon city." Under its 12th Five-Year Plan (FYP), the Changning District government articulated a vision to "transform Changning into a leading low-carbon district…anchoring to green growth as the engine for the competitiveness of the district" (World Bank 2013). It sought to achieve this vision by leveraging international expertise and piloting innovative policies and programs, yet to be implemented anywhere in the country (World Bank 2013).

Given this vision, the Changning District government invited the World Bank and an international

Changning District Basic Facts

- Population: 693,700
- Per capita GDP: 190,450 Renminbi (RMB) (2017)
- Per capita floor area: 36.1 square meters (m^2) Shanghai data)
- Per capital energy usage: 5,808.8 kWh (2016)
- Climate Zone: Hot Summer Cold Winter Zone

Figure 1. The geographical location of Changning District. Source: Wikipedia 2019. Changning District Basic Facts. Source: Sherlock et al. 2018; Shanghai Statistical Yearbook 2018; C40 Cities 2018.

consulting firm to partner with the Shanghai Energy Conservation Supervision Center (SECSC) to develop a carbon dioxide (CO_2) abatement cost curve. The cost curve identified the abatement potential, cost, and ease of implementation of various CO_2 mitigation options and helped to inform Changning District's CO_2 abatement targets and identify priority actions and investments.

Following the cost curve analysis, Changning District government, in collaboration with Chinese and international partner institutions, conducted a series of upstream analytical studies to assess technical, economic, and financial feasibility; identify implementation barriers; and recommend policy changes in order to implement the abatement cost curve measures.

These analytical studies included the following: (1) an existing building energy efficiency (EBEE) improvement policy study to develop building benchmarks (or targets), recommend policy changes, and identify business models for EBEE improvement, since EBEE improvement was identified as the single largest emission-reduction opportunity in the district; (2) a technical, economic, and financial feasibility study on low-emission new buildings and near-zero-emissions buildings; (3) feasibility studies of typical investments in EBEE in various building categories; and (4) consultations with key stakeholders, including building owners, property management companies, energy service companies (ESCO), and financial institutions (World Bank 2013).

Together, these upstream analytical and project preparation studies led to the International Bank for Reconstruction and Development/Global Environment Facility (IBRD/GEF) Green Energy for Low Carbon City project. The project provided loans of US$100 million, combined with an additional US$146 million from institutional investors, to facilitate EBEE improvement, near-zero-emission buildings, distributed generation, and green mobility in Changning (World Bank 2019).

This *Targets Playbook* Chapter 2 will touch on the abatement cost curve and all preparatory studies undertaken by Changning District leading to the IBRD/GEF project, but will focus primarily on the development and implementation of the EBEE targets and improvement component of the project, and more specifically, the energy-use intensity (EUI)-based target-setting methodology utilized by the district.

I. ASSESS

1.1 Collect Existing Resources and Information

Activity 1: Assess Existing Targets

In an effort to transition to a leading low-carbon district in Shanghai, an initial question raised by the Changning District government was: are there a national or local energy or greenhouse gas (GHG) emissions reductions targets for the building sector that our district could leverage and/or align with to help establish a voluntary EBEE targets and improvement program? Through desk research and stakeholder engagement, the Changning District identified the following:

- *Chinese* national energy and GHG emission reduction targets. The government of China (GOC) had committed to reducing national CO2 intensity by 40-45% from 2005 to 2020. Energy efficiency (EE) and renewable energy (RE) were expected to contribute significantly to achieving this target. In addition, under the 12th FYP (2011-2015), China had committed to cutting energy intensity by 16% and increasing the share of non-fossil fuels (RE and nuclear) in primary energy from 8% in 2011 to 15% by 2020.
- Shanghai's low-carbon target. Shanghai municipal government included "transition to a low-carbon city" as one of the high priorities of their 12th FYP (SECSC et al. 2013).
- Changning District's low-carbon target. Changning District government presented an articulated vision aiming at transforming Changning District into a leading low-carbon district in Shanghai and China. In 2011, Hongqiao Business District, belonging to Changning, was selected as one of the eight low-carbon demonstration areas in Shanghai (World Bank 2013).

Activity 2: Assess Existing Policies and Programs

Once relevant targets had been identified, Changning District undertook a comprehensive review of national, provincial, and municipal building EE programs and policies. This included:

- National building EE codes and retrofit policies, and financial incentives.
- Shanghai building EE codes, retrofit policies, and financial incentives.
- Building EE codes, retrofit policies, and financial incentives from other Chinese cities and foreign countries, provinces, and cities.
- Achievements from various building EE policies and programs.
- Current municipal building EE retrofit business models (SECSC et al. 2013).

Key results of Changning District's assessment are shown in Tables 1, and 2 below:

Table 1. Chinese National and Shanghai Municipal Building EE Policies

No.	Title of Policy	No.	Title of Policy
1	Energy Conservation Law	5	Contract Energy Management Project Financial Incentives Fund
2	Law of the People's Republic of China on Renewable Energies	6	Special Fund Management Interim Measures for Government Office Buildings and Large Public Building Energy-Saving
3	Civil Building Energy Saving Regulations	7	Notice on Further Promoting the Public Building Energy Saving Work
4	Regulations on Energy Conservation of Public Institutions	8	Notice on Further Promote Renewable Energy Application in Buildings
9	Shanghai Energy Conservation Ordinance	10	Shanghai Special Support Measures for Renewable and New Energy Development
11	Shanghai Building Energy Saving Regulations	12	Shanghai Special Funds Management Measures for Contract Energy Management Project
13	Shanghai Special Funds Management Measures for Energy-saving Emission Reduction	14	Guidance on Energy Rational Use for Municipal Office Buildings; Guidance on Energy Rational Use for Hotels; Guidance on Energy Rational Use for Large Commercial Buildings
15	Shanghai Special Support Interim Measures for Building Energy-saving Projects	16	Shanghai's Work Plan to Speed up High Efficiency Motor Application and Remanufacturing
17	Shanghai Special Support Measures for Implementation energy conservation and emission reduction technology renovation project	18	Notice on Energy and Water Saving, Environment Protection, Safety Production and Special Equipment Maintenance Management, and Enterprise Income Tax Exemption

Source: SECSC et al. 2013.

Table 2. International Policies and Programs

No.	Title of International Policy/Program
1	US Federal Energy Management Program (FEMP)
2	Sustainable Melbourne Fund
3	Green Building Program in Seattle
4	New York City's Greener, Greater Buildings Plan
5	Build Smart New York Initiative
6	ESCO and Solar Service Model for a U.S. Corporation (Staples)

Source: SECSC et al. 2013.

Of particular focus for Shanghai Changning District were the current national and municipal mandatory and financial incentive policies shown in Tables 1 and 2. The mandatory policies showed the government's current priorities and covered energy usage quotas for public buildings; overall energy saving and consumption reduction requirements; energy consumption statistical research; and phase-out of high energy consuming equipment and products. Understanding the mandatory policy context provided Changning District with a foundation to establish an energy monitoring system that included sub-metering, energy consumption benchmarking, and energy data disclosure.

With regard to incentive policies, Changning District government determined there were currently three ways to subsidize EBEE improvement in Shanghai (shown below). In general, government determined that the financial subsidies for EBEE improvement in Shanghai were generous and should be leveraged.

- The *Shanghai Special Support Measures for Implementation of Energy Conservation and Emission Reduction Technology* Renovation Project stipulated that a reward of RMB 300 (US$43.48)18 per tons of standard coal (TSC) per year would be provided if a project could save 500 TSC or more.
- The Shanghai Special Support Interim Measures for Building Energy-Saving Projects offered a maximum subsidy of RMB 50 (US$7.25) per m² if a single public building over 20,000 m² (or a single government building over 2,000 m²) met the 50% energy saving standard.
- The Shanghai Special Funds Management Measures for Contract Energy Management Project provided financial incentives from the central government of RMB 600 (US$86.96) per TSC saved, and a financial incentive from the local government of RMB 600 (US$86.96) per TSC saved.

Lastly, as a result of the assessment, Changning District determined that it had made steady progress in building energy conservation in the following aspects:

- Enforcement of mandatory EE codes;
- Exploration of opportunities for existing building retrofits;
- Promotion of integrated RE application;
- Supervision on building EE; and
- Training on building EE (SECSC et al. 2013).

Activity 3: Assess Available Data

Data are at the core of EBEE target setting and improvement. Regardless if one is determining a building energy savings potential, profiling abatement cost curves, or designating a baseline, massive building energy use data are necessary.

One of the preconditions for Changning District's EBEE targets and improvement program was the Commercial Building Energy Consumption Monitoring Platform (ECMP), which is shown in Figure 2.

[18] In this report, we mostly use a rate at: 1 US$ = 6.90 Renminbi (RMB). Time point: May 20th, 2019.
*Note: date back to the first beginning of Changning District's World Bank- Shanghai Low Carbon City Project, the rate was a lower one at around 1 US$ = 6.30 Renminbi (RMB).

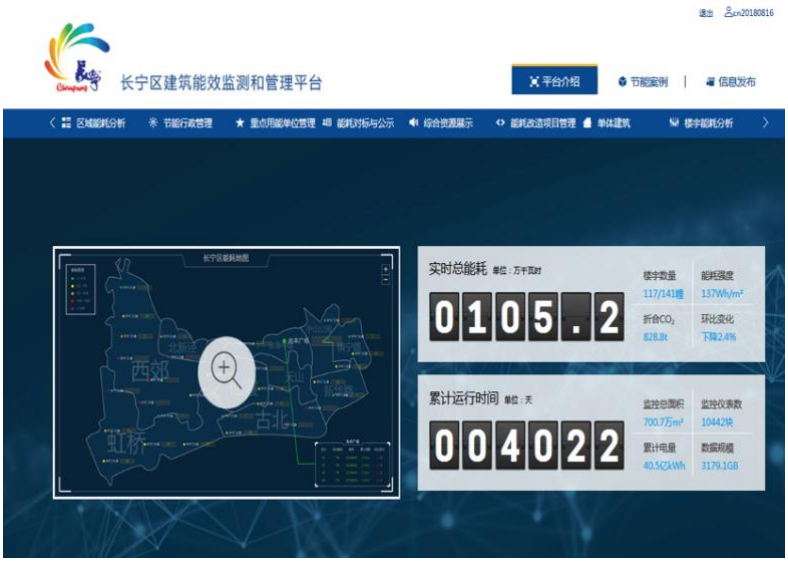

Figure 2. Changning District ECMP interface. *Source*: SABR 2019, 9.

As an integrated online platform, ECMP enabled the real-time monitoring, analyses, processing, exchange, and public disclosure of energy consumption data for large commercial buildings in the area. Dating back to the year 2007, with financial support from the Ministry of Housing and Urban-Rural Development (MOHURD) and Ministry of Finance (MOF), a lot of capital cities in many provinces started to develop this kind of ECMP to monitor and manage real energy consumption data for large commercial buildings in China (Wu 2019).

But for Changning District, the district-level ECMP was developed and officially put into operation in July 2011. At that time of the EBEE targets and improvement program, the Changning District ECMP was connected to 100 commercial buildings, which covered 63% of commercial buildings across the district, and monitored hundreds of millions of kilowatt hours (kWh) of electricity consumption each year (EFC(a) 2012). The building types' distribution and EUI by type are shown in Figure 3 and 4 below.

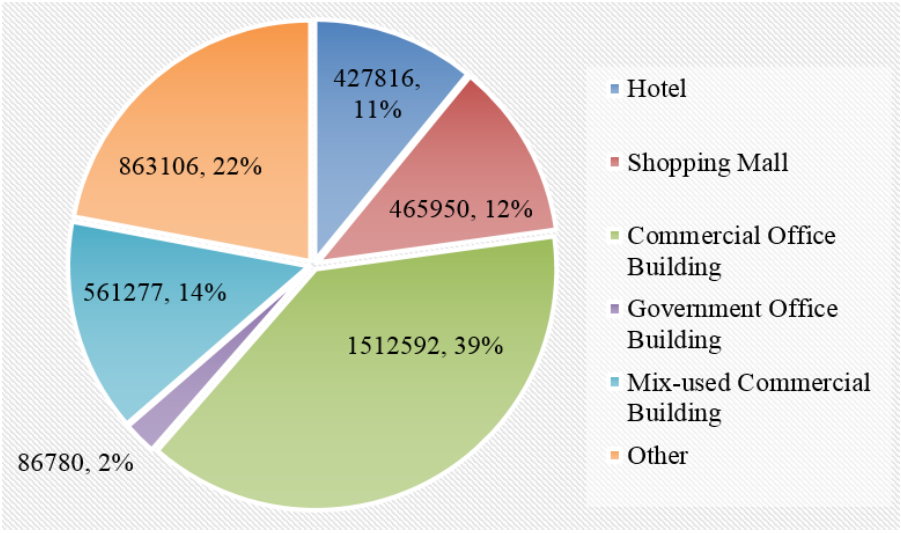

Figure 3. Building types distribution on Changning District's ECMP. *Source:* EFC(a) 2012, 8-9.

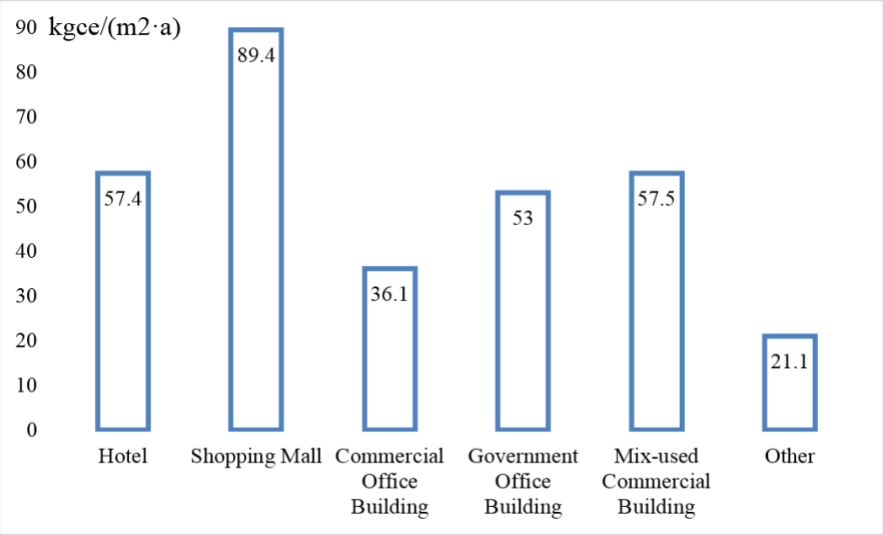

Figure 4. EUI by building type on Changning District's ECMP. *Source*: EFC(a) 2012, 8-9.

The data collected through the Changning District ECMP includes:

- Building Characteristics:
    - Location (e.g., address).
    - Type and function (e.g., office building, shopping mall, hotel, cultural and education building, hospital, sports building; mix-used building).
    - Building size (i.e., including gross floor area and indoor garage floor area).
    - Construction year (e.g., before 1990; 1991-1995; 1996-2000; 2001-2010; or 2011-present).
    - Occupancy (e.g., number of users of electricity).
- Building Energy Data:
    - Total building energy consumption and energy consumption per unit of floor area.
    - Energy consumption by end-uses/system (e.g., air conditioning electricity, power electricity, lighting electricity, special electricity, elevator, plug).
    - Energy consumption by fuel type (e.g., electricity, thermal/heat energy, natural gas, solar power).
- Other:
    - Building water consumption data.
    - Building retrofit information[19] (e.g., project name, demonstration retrofit floor area, retrofit extent, energy savings, energy saving rate) (Zhu and Xu 2016; Chen 2014).

The data collected through the Changning District ECMP have proved critical in both understanding the existing building stock as well as facilitating the district's development and measurement of progress toward EBEE targets (SABR 2019).

[19] This function was developed in Shanghai after they initiated the EBEE program.

1.2 Understand Benefits and Potential Barriers

Activity 1: Assess Benefits

Coinciding with an assessment of existing targets, policies and programs, and available data, Changning District government invited the World Bank and an international consulting firm to partner with the SECSC to develop a CO_2 abatement cost curve[20] to set a low-carbon target and identify priority mitigation options for the District.

The Hongqiao Economic and Technology Demonstration Zone (ETDZ), shown in Figure 5, was selected for the abatement curve study. With a population of 80,000, its GDP accounted for 28.5% of the total of Changning District, 93% of which was contributed by the service sector, and was therefore considered representative in terms of typical abatement options in Changning District.

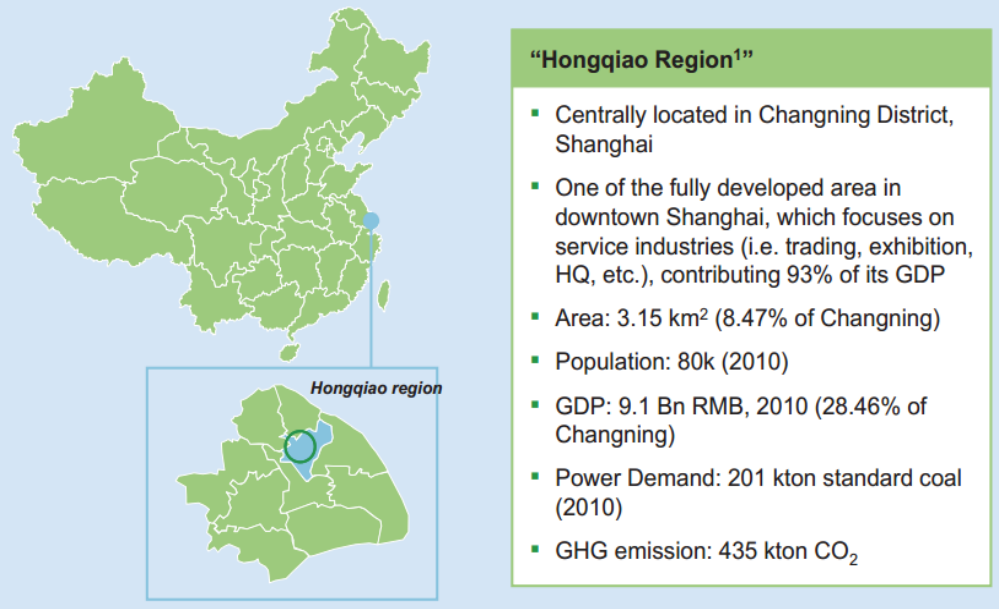

Figure 5. Hongqiao demonstration area of Changning District, Shanghai. *Source*: World Bank 2013, 25.

A survey of 100 buildings (6 offices, 13 hotels, 7 shopping centers, 46 commercial buildings, 9 mix-use buildings, and 19 others) in the Hongqiao ETDZ was undertaken; three alternative abatement scenarios (*Frozen Technology Scenario; Baseline Scenario to Meet the National Government's Target; and Stretch Scenario beyond National Government's Target*) were developed; and a CO_2 abatement cost curve showing abatement potentials, costs, and ease of implementation for various mitigation options was developed (shown in Figure 6). The study was the first of its kind in China and allowed the District government to make an informed decision about medium-term targets of CO_2 abatement and identify priority actions and investments to meet them (World Bank 2013).

20 For the details on how Changning District used the World Bank's cost curve tool, please see:
World Bank. 2013. *Applying Abatement Cost Curve Methodology for Low-Carbon Strategy in Changning District, Shanghai*. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/16710.

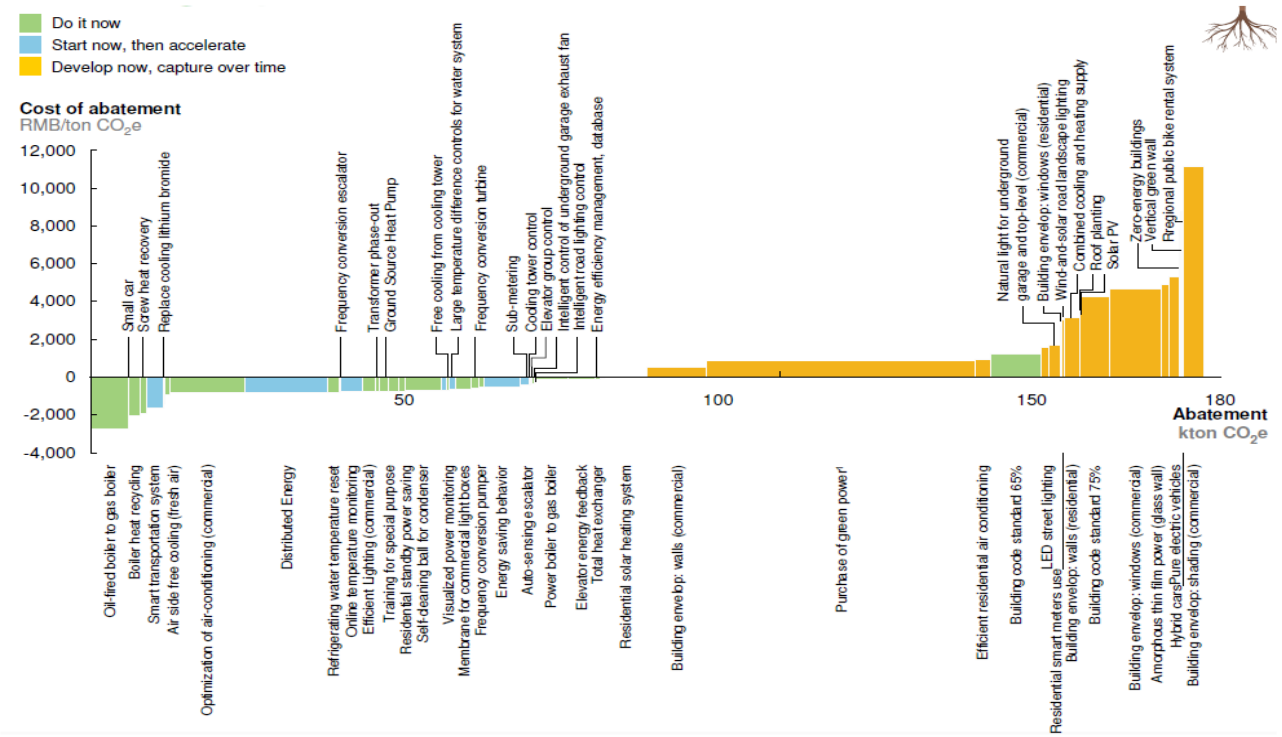

Figure 6. Abatement Cost Curve with Ease of Implementation in Hongqiao Area, Changning District in 2015.

Source: World Bank 2013.

Based on the abatement cost curve study, Changning District determined that to achieve the low-carbon objective in the *Stretch Scenario,* it would need to reduce energy consumption of the 100 buildings surveyed in Hongqiao demonstration area by 18%, or equivalent to an energy saving of 33,000 tons of coal equivalent (TCE) (SECSC 2013). It also determined that EBEE improvement was the single largest emission-reduction opportunity in the district and commercial building retrofits offered by far the largest CO_2 emission reduction opportunity in Changning District, compared to government and residential buildings (SECSC 2013; World Bank 2019).

Activity 2: Assess Barriers

Based on the abatement cost curve analysis, Changning District determined that retrofitting commercial buildings, as part of an overall voluntary EBEE targets and improvement program, offered by far the largest energy conservation opportunity in Changning District. They also noted numerous barriers to establishing a voluntary EBEE targets and improvement program that would involve retrofits including the following (SABR 2019):

- *Lack of Mandatory Retrofit Policy*. The principal barrier to commercial building retrofit is that owners are reluctant to invest in EE measures without a mandatory policy, because: (a) energy costs are a small proportion of building operating costs and are usually passed on to the tenants; (b) building retrofit investments often have a long payback period; (c) owners do not want to disrupt operation of the buildings for retrofit; and (d) complicated procedures associated with loan applications, permits, etc.

- Split Incentives. Building EE projects usually face split incentives: the investors in retrofit measures and the beneficiaries of energy savings are usually different parties. Beneficiaries do not pay the costs and payers are not beneficiaries in the majority of cases where the owner does not occupy the building. It is critical to understand the intricate relationships among government entities, building owners, property management companies, renters, utilities (including heat supply companies), and ESCOs, so that policies and financing mechanisms will be targeted to the right groups.
- Lack of Financial Incentive Mechanisms and Business Models. Financial institutions are usually hesitant to finance building EE retrofits due to: (a) the small size of the deal (between US$150,000 and US$500,000); (b) long payback period (often more than 10 years), while most private sector investors are not willing to make an investment beyond 3-5 years payback period; (c) high transaction costs, high credit risks of ESCOs, which oftentimes have a weak balance sheet, (d) and high perceived technical risks that the anticipated energy savings from the retrofit may not be realized. Further, there are few successful business models that make EE retrofit projects (which are typically small and dispersed) attractive to investors by reducing these performance risks (e.g., unrealized savings) and minimizing transaction costs for financing (SECSC 2013).

1.3 Identify Stakeholders, Tools, and Resources Needed

Activity 1: Identify Stakeholders and Assign Roles

Changning District's first step in this stage was to identify all stakeholders relevant for designing and implementing a voluntary EBEE targets and improvement program. Stakeholders Changning District identified are as follows:

- Municipal government and sector government (e.g. in charge of schools and hospitals)
- Owners
- Operation management team/property management companies
- Retrofit developers/ESCOs
- Financial institutions (e.g. banks)
- Renters/government service occupants
- Government agencies in charge of retrofit (Mao 2019)

Changning District's second step at this stage was to set up a new institution under the Shanghai Changning District Development and Reform Commission – the Shanghai Changning District Urban Renewal and Low Carbon Project Management Center (URLCPMC).[21] The purpose of the center was to coordinate and integrate the strengths of different stakeholders like financial institutions, universities, research institutions, and ESCOs, and to take charge of the low-carbon transition of the district, as illustrated in Figure 7 below (SABR 2019). Establishing and implementing the EBEE targets and improvement program was identified as one of the main tasks of the URLCPMC. SECSC and Shanghai Changning District Government also participated in and advised work related to EBEE targets in Changning District. In fact, Shanghai municipal government and Changning district government payed lots of

[21] For cities, they always need to assign an existing institution or set up a new one at the beginning of implementing an ECBEE program. The institution will lead and manage the program from the first beginning to the end.

attention to the EBEE retrofitting project. Government officials set up a task force to master the progress, which providing powerful leadership guarantee for the implementation (Mao 2019).

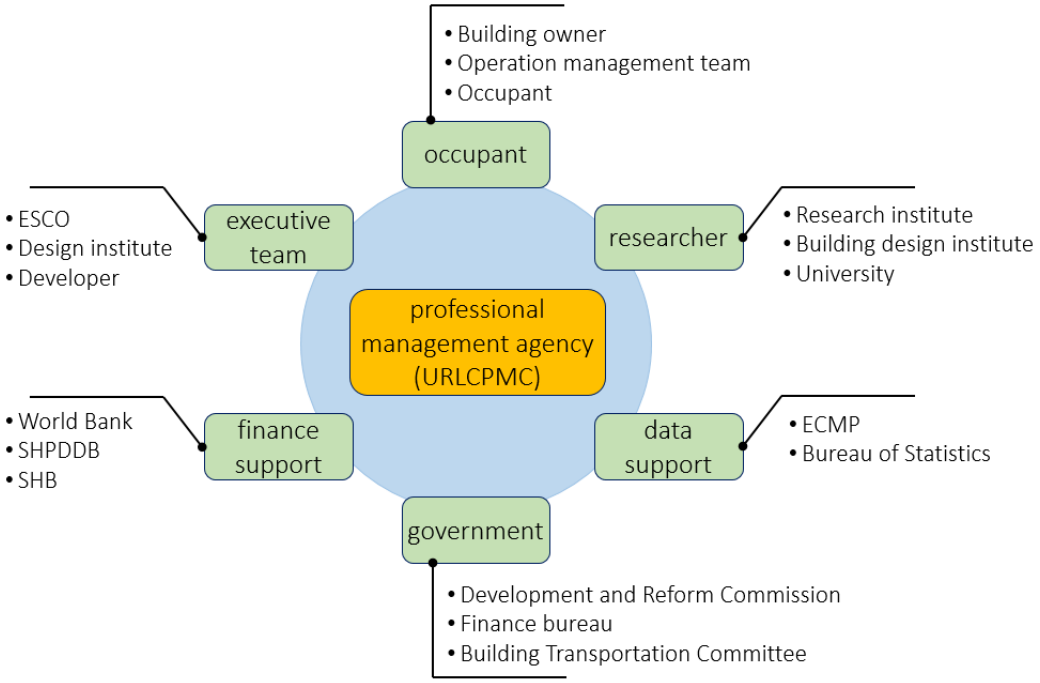

Figure 7. How stakeholders are integrated by URLCPMC in Changning District. *Source:* SABR 2019, 17.

Changning District then established an organizational structure to support an overall EBEE targets and improvement program involving government departments, financial institutions, and market subjects, as shown in Figure 8 below (SABR 2019, 4).

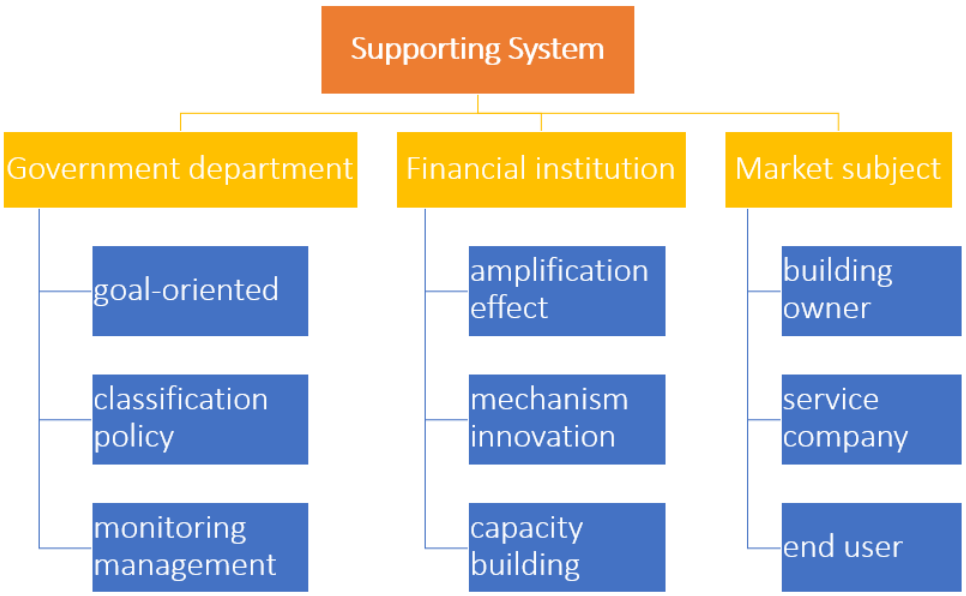

Figure 8. Supporting system of EBEE program in Changning District. *Source*: SABR 2019, 4.

In its process to design and implement an EBEE targets and improvement program, Changning District also conducted extensive consultations with key stakeholders, including: interviews, seminars, and workshops with building owners, property management companies, tenants, ESCOs, international and national experts, financial institutions, as well as related operators and decision makers (SECSC 2013).

Activity 2: Identify Tools and Resources

Lastly, Changning District identified tools and resources necessary to support development and implementation of an EBEE targets and improvement program. These included the following:

Tools

- *Online Real-time Commercial Building ECMP*. By the end of 2018, Changning District's ECMP had 187 commercial buildings, covering more than 95% of the large commercial buildings and state offices within the district (SABR 2019).
- *World Bank Energy Sector Management Assistance Program (ESMAP) Marginal Abatement Cost Tool* (MAC Tool). Changning District government and its partners utilized ESMAP's MAC tool in the early stages of the project to quantify the CO_2 abatement potential, cost, and ease of implementation for various mitigation options, which helped to clarify the importance of EBEE improvements to meet overall low-carbon targets in the district (World Bank 2013; SABR 2019). This tool was selected because it was free, applicable globally (including in Asia), and expert consultants supporting Changning District on the project were familiar with the MAC Tool. This tool had been utilizing during the whole targets and improvement program implementation process, and got continuous and dynamic updating with accumulated real retrofit date (Mao 2019).
- *Benchmarking Tool*. An updated version of Changning District's online commercial building energy consumption supervision platform contains the function of benchmarking (SABR 2019).
- *Building Energy Modeling (BEM) Tools*. Changning District utilized EnergyPlus®, DeST, DOE-2, and eQuest® to develop retrofit plan and figure out the energy savings potential (EFC(a) 2012; EFC(b) 2012).
- *Project Implementation Plan – Computer Aided Tool (PIP-CAT) Development*. Changning District utilized computer-aided tools, such as the Comprehensive Evaluation Tool for EBEE project implementation plan development (EFC(b) 2012).

Resources

- International case studies of EBEE improvement policies and programs.
- Government financial support through subsidy policies.
- External expert guidance from Word Bank, GEF, ICF International and Energy Foundation China, etc. (SECSC 2013).

II. DEVELOP

2.1 Define Scope of the Policy of Measure

Activity 1: Select the Type of EBEE Targets and Improvement Program

As described in "Assess B: Understand Benefits and Potential Barriers," Changning District, utilizing the CO_2 abatement cost curve, determined that to achieve the low-carbon objective in the *Stretch Scenario*, the district would need to reduce current energy consumption in 100 existing building in the Hongqiao ETDZ by 18%, equivalent to 33,000 TCE. With this as the overall goal, Changning District considered two distinct methods for target-setting at the individual building-level (SECSC 2013):

- *National Building Codes as* the Targets (see details in 1a). Codes as targets are important for cities to consider because they can be easier and more legitimate to enforce.
- Performance-based Benchmarking in kWh per Square Meter (kWh/m2). Under this methodology, four approaches (see details in 2a, 2b, 2c, 2d below) were used to rank 100 buildings in Hongqiao ETDZ and determine which building should participate in the EBEE targets and improvement program, and what the individual EBEE targets should be, in order to achieve the overall district-level target of 33,000 TCE. Performance-based benchmarks are important for cities to consider because they are directly link to overall energy and emissions savings targets, and measurement and verification of savings is straightforward to implement (SECSC 2013, 60).[22]

Each of the aforementioned methods for target-setting which Changning District explored is described in detail in the paragraphs that follow.

National Building Codes as Targets

China's *Energy Conservation Design Code for Public Buildings in Areas with Hot Summer and Cold Winter* requires that existing buildings meet the national building energy code of 50% energy savings compared to baseline buildings of the 1980s if they planned to renovate or expand (not for EE purposes). However, if an existing building had no plans for renovation or expansion, there was no requirement to improve EE performance. Thus, Changning District determined that one potential target would be for all buildings in Hongqiao ETDZ to retrofit to meet the 50% building energy code. Using this approach, Changning District found that 90% buildings would undertake EE improvements due to lack of code compliance. The total energy savings was estimated at 33,400 TCE, with total investment of 430 million RMB (US$62.32 million) or RMB120/m^2 (US$17.39/$m^2$) (SECSC 2013, 58).

[22] For more information, go to Table 6. Summary of Pros and Cons of Target-Setting Approaches.

Ranking kWh/m2 for all Buildings (Overall Ranking)

This method ranked all 100 buildings in the Hongqiao ETDZ in terms of electricity usage per unit of floor area (kWh/m^2) from low to high. A uniform average benchmark was set according to the low-carbon target. Buildings with the kWh/m^2 above the target were encouraged to implement EE improvements to meet the target. As shown in Figure 9, while the average electricity use intensity of the 100 buildings was 141.8 kWh/m^2, the threshold for EE improvements was 153.2 kWh/m^2 in order to meet the total energy savings of 33,000 TCE. The total investment was estimated to be 430 million RMB (US$62.32 million), or RMB 456/ m^2 (US$66.09/$m^2$).

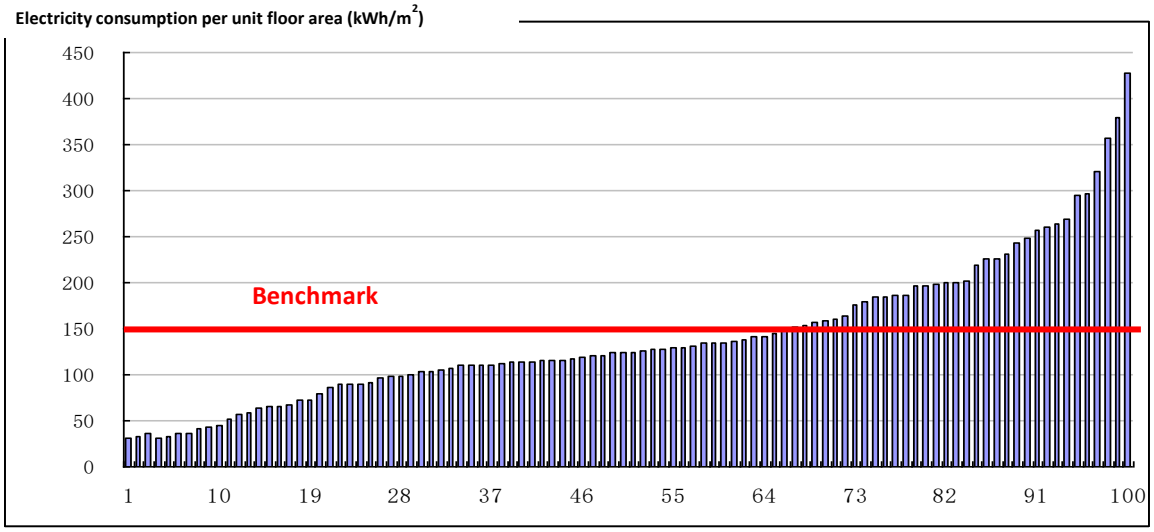

Figure 9. Ranking kWh/m2 for all Buildings (Overall Ranking). Source: SECSC 2013.

According to Changning District, the drawback of this method was that while it provided a quick and cost-effective first measure of the energy performance of a building relative to its peers, it was not an equitable method of comparison as it did not consider different functions (e.g., hotels versus office) and energy service requirements of these buildings. It was not equitable to compare offices with data centers to full-service hotels. The result was that some buildings that had potential for EE improvement were not be encouraged to improve performance, while some other buildings that were encouraged to improve performance did not have sufficient EE opportunities to meet the target (SECSC 2013, 53-54).

Ranking kWh/m2 for Buildings by Categories (Categorized Ranking)

To accommodate differences in building functions and energy service requirements, the second target-setting method explored by Changning District ranked energy consumption in kWh/m^2 for buildings by type. As illustrated in Figure 10 below, the 100 buildings in Hongqiao ETDZ were categorized into six types: office buildings, hotels, shopping centers, commercial buildings, mixed-used buildings, and others. The corresponding average EUI targets were 105.1 kWh/m^2, 168.0 kWh/m^2, 236.7 kWh/m^2, 103.4 kWh/m^2, 178.6 kWh/m^2, and 38.9 kWh/m^2. Using this method, a total of 56 buildings were encouraged to improve EE for an estimated savings of 36,000 TCE and a total investment of 598 million RMB (US$86.67 million), or RMB 244/m^2 (US $35.36/m^2).

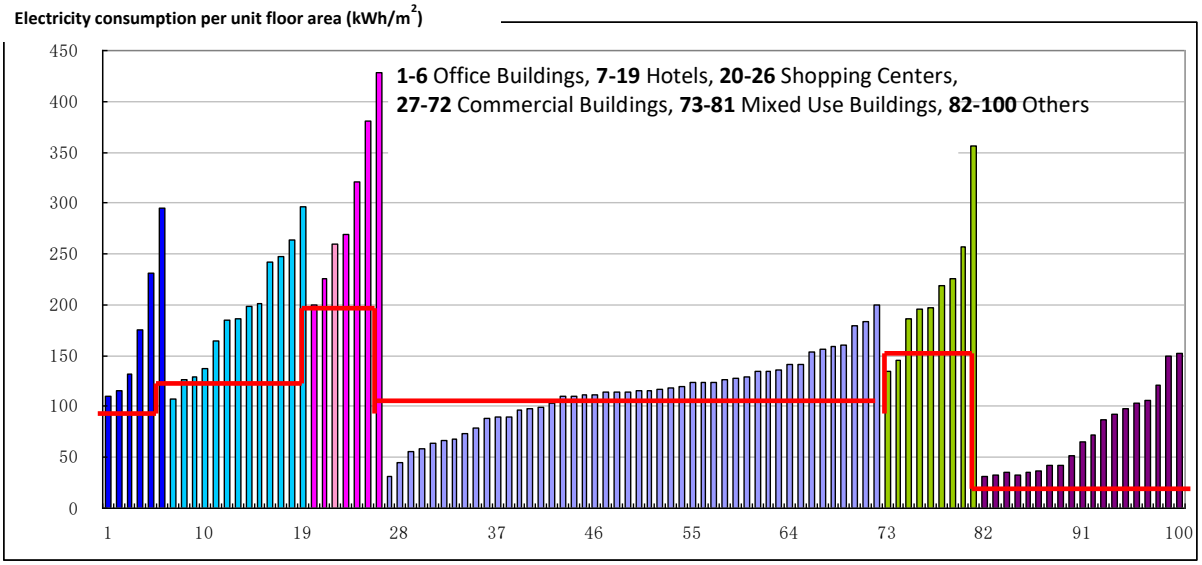

Figure 10. Ranking kWh/m2 for Buildings by Categories (Categorized Ranking). *Source:* SECSC 2013.

According to Changning District, while this categorized ranking method was an improvement over the general ranking method, it still did not account for the fact that even buildings within the same category (e.g., three-star and five-star hotels) could have very different energy consumption patterns due to differences in occupancy, amenities, etc. meaning that some EE opportunities would not be adequately captured. As a result, despite the improvements over the general ranking approach, Changning District determined 58% of buildings above the target did not have viable EE projects to achieve the required energy savings (SECSC 2013, 54).

Ranking kWh/m2 for Buildings in Each Category and Using Top Runner Buildings as the Benchmark for that Building Category (Top Runner Ranking)

Changning District's third method of target-setting established the target for different building categories by using the average kWh/m^2 of top runner buildings in that building category. The top runner buildings were those that had met the *Energy Conservation Design Code for Public Buildings* (50% energy savings compared to reference buildings in 1980) by design. This approach is illustrated in Figure 11.

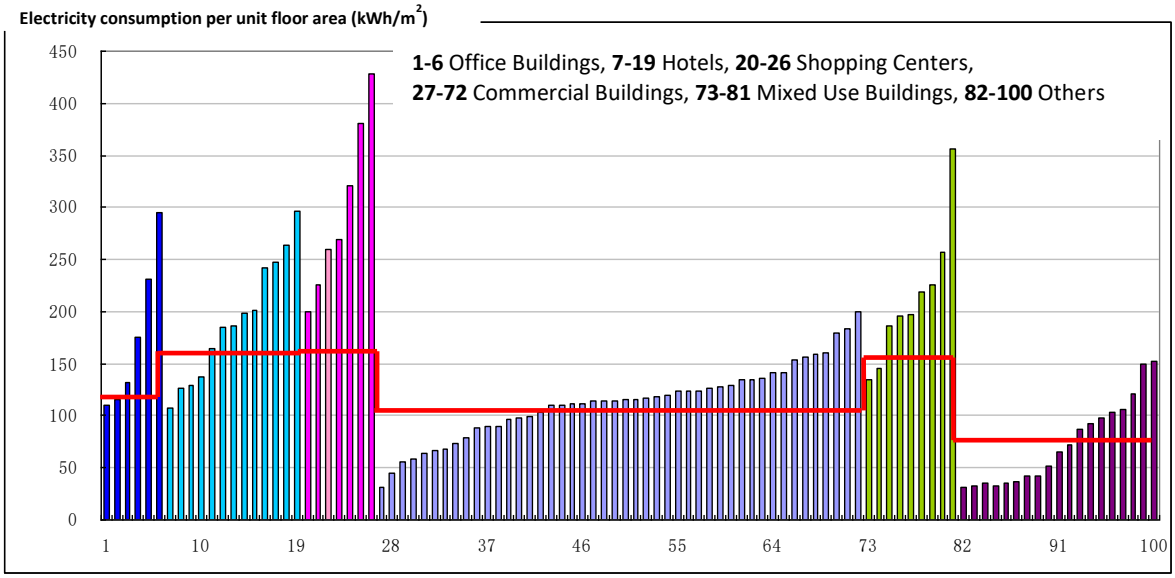

Figure 11. Ranking kWh/m2 for Buildings in Each Category and Using Top Runner Buildings as the Benchmark for that Building Category (Top Runner Ranking). *Source:* SECSC 2013.

Similar to the categorized ranking method, the 100 buildings in Hongqiao ETDZ were categorized into six types: office buildings, hotels, shopping centers, commercial buildings, mixed-used buildings, and others. The corresponding kWh/m^2 benchmarks were 111.7 kWh/m^2, 151.6 kWh/m^2, 152.4 kWh/m^2, 97.9 kWh/m^2, 144.7 kWh/m^2, and 76.4 kWh/m^2. Using this method, a total of 64 buildings were encouraged to improve EE performance. The estimated savings was 48,000 TCE, with total investment of 800 million RMB (US$115.94 million) or RMB288/m^2 (US $41.74/m^2).

Compared to the second method, the top runner buildings method adopted a higher EUI target for each category, resulting in higher overall energy savings. However, it still did not address the problem that energy consumption patterns vary significantly even within the same building category due to differences in occupancy, amenities, etc. resulting in some EE failing to be adequately captured (SECSC 2013, 54-55).

Ranking KgCE/m2 for Buildings in Each Category and Setting the Adjusted EUI as the Target for that Building Category (Normalized Target-Setting)

To address differences in building functions and energy service requirements, Changning District's fourth method categorized buildings into the following types: five-star hotels, four-star hotels, three-star and below hotels, shopping centers, commercial office buildings, government office buildings, mix-used

buildings, and others. Changning District then identified key factors which could influence the building energy consumption (e.g., gross floor area, operating hours, and occupancy) and used a linear regression approach to analyze the dependent variable (total energy consumption), subject to various independent characteristics (e.g., gross floor area, operating hours, occupancy). Based on regression analysis, Changning District selected the equation which included the combination of statistically significant operating characteristics that explained the greatest amount of variance in the dependent variable. The equations were tested using the following statistical methods:

- $R^2 > 0.5$
- Significance test, consisting of two parts: test of regression coefficient and test of regression equation. F-statistic <0.0001
- Autocorrelation test: based on the empirical rule, the statistic of Durbin-Watson should fall into the range of 1.5-2.5
- Multiple linear test: the correlation between two independent variables <0.75

Using the optimal regression equation, Changning District re-calculated and adjusted the kilograms of coal equivalent per square meter (KgCE/m^2) for each building. The buildings were then ranked according to their adjusted KgCE/m^2 and appropriate targets were determined. The analysis followed the specific steps below (SECSC 2013, 55-56):

- Conduct building survey.
- Filter and pre-analyze the data collected to eliminate abnormal data points.
- Allocate the total energy saving target to each building type.
- Conduct the regression analysis and identify the gross floor area as the key independent variable for each building type.
- Using the total energy consumption as the dependent variable, develop the regression equation for each building type which meets the statistical significance tests indicated above.
- Adjust the KgCE/m^2 for each building based on the equations developed.
- Rank the adjusted KgCE/m^2, and identify the targets of 10%, 25%, 50% and 75%, which are candidates in each building type. (Note: a target of 10% means that 10% of buildings perform better than the target and 90% of buildings would be encouraged to pursue EE improvements. A target of 75% means 75% of buildings perform better than the target, and 25% would perform worse than the target and be encouraged to pursue EE improvements).
- Setting the level of 75% as the preliminary target for trial, identify the building with actual KgCE/m^2 higher than the target as the buildings to be improved; analyze the energy saving potentials from those buildings; cross check with the total energy saving goal; and change target percentile, as needed, to finally obtain the target which ensures the buildings above it will meet the total energy savings goal (SECSC 2013, 56).

Based on this method, the final EBEE targets for five-star, four-star, three-star hotels, commercial office buildings, and shopping centers was set at 71 KgCE/(m^2.a), 47KgCE/(m2.a), 37 KgCE/(m^2.a), 34 KgCE/(m^2.a), and 76 KgCE/(m^2.a), respectively. The expected energy savings based on this method was 17,151 TCE with a total investment of 262 million RMB (US$37.97 million) or RMB 161/m^2 (US$23.33/$m^2$). The detailed economic and financial impact analysis based on the fourth method is summarized in Table 3 (SECSC 2013, 55-57).

Table 3. Economic and Financial Summary Based on the Normalized Benchmark

Building Type	**Hotels**	**Commercial Office Buildings**	**Shopping Centers**
Retrofit Investment	6.81	26.42	4.84

(10^6) US$			
Energy Savings (TCE)	2,570.6	7,709.7	6,871.2
Investment per TCE (US$/TCE)	2,648.55	3,427.25	705.22
Investment per m^2 (US$/$m^2$)	19.12	29.30	12.80
No. of buildings to be retrofitted	10	28	5
% with payback 0-3 years	30%	4%	100%
% with payback 3-5 years	0%	18%	-
% with payback 5-10 years	20%	39%	-
% with payback 10-15 years	30%	21%	-
% with payback > 15 years	20%	18%	-

Source: SECSC 2013, 57. Note: The analysis refers the following tariff: the energy prices for electricity, natural gas and diesel are 0.9RMB/kWh (US$0.13/kWh), 3.7RMB/m3 (US$0.54/m3), and 7.79RMB/Liter (US$1.13/Liter)

While the normalized target-setting method was a significant improvement against the previous three methods, since it factored out key functions of the building that are out of the owner's or manager's control, but can influence energy consumption (e.g., size, operating hours), Changning District did identify the following limitations in how it implemented this method:

- First, EUI targets were determined only by normalizing for (i.e., factoring out) size and occupancy due to data access limitations. Typically, multiple variables (e.g., size, operating hours, plug load, percentage of floor area heated, percentage of floor area cooled), are included in a regression analysis to determine their effect on the dependent variable and to identify an appropriate model to fairly compare building energy performance.
- Second, although the targets were determined by normalizing for building size and occupancy, directly comparing the actual value of building EUI with the adjusted EUI target to identify the buildings to be improved was not a fair comparison. A more equitable approach would have been to compare the adjusted EUI for each building to the adjusted target.
- Third, according to data provided, only 68 of the 100 buildings Hongqiao ETDZ were analyzed utilizing this normalized methodology, and the energy savings was only 17,151 TCE. An optimum approach would have been to rank all 100 buildings in Hongqiao ETDZ according to their normalized KgCE/m^2 and to set a target where all buildings above would improve EE performance for a total savings meeting the goal of 33,000 TCE (SECEC 2013, 57-58).

Activity 2: Evaluate Various Approaches to Establishing EBEE Targets

Each target-setting methodology has its pros and cons, which are summarized in Table 4 below. The advantage of the performance-based target-setting methodology is that it can be directly linked to the total energy savings reduction target. Furthermore, the measurement and verification (M&V) of energy savings is based on total energy consumption and floor area, which are relatively easy data points to obtain. The disadvantage is that targets may not easily be accepted by building owners and managers unless they are considered fair, which means they must normalize for the numerous variables that influence building energy consumption but are outside the owner or manager's control (e.g., size, location, occupancy, operating hours) (SECSC 2013). This requires the use of sophisticated software for regression analysis and numerous building data points, which may not be easily obtained. However, there are publicly available tools, such as the U.S. Environmental Protection Agency (EPA) ENERGY STAR®

PortfolioManager®[23] tool that are free and simple to use which automatically normalize for the key drivers of energy consumption in buildings and can facilitate normalized target-setting.

Table 4. Summary of Pros and Cons of Target-Setting Approaches

Benchmarking Approach	Pros	Cons
Performance-based targets (kWh/m2)	Links directly to energy savings target. M&V is based on total energy consumption and floor area, and is straightforward to implement.	When establishing targets, need to factor out (or normalize) all the variables that influence building energy consumption but are outside the owner/manager's control (size, weather, climate, occupancy, operating hours, type, plug load, etc.) through regression analysis to ensure the targets are fair and can be accepted by building owners/managers. May require additional data collection and skills in regression analysis.
Targets based on current building codes	It is more legitimate to enforce.	No directly link to the energy saving and emission reduction target. Input-based and technology-focused approach. Less flexibility to select the most effective EE measures that link to the actual performance.

Source: SECSC 2013, 60.

The advantage of adopting existing building codes as targets is that they are considered legitimate and are relatively easy to check for compliance. However, the disadvantage is that most codes today are prescriptive, which means they prescribe certain efficiency levels for the heating, ventilation, and air-conditioning (HVAC) system, lighting, insulation, etc. of a building, which means that a building can be code compliant but not necessarily energy-efficient if systems and equipment are managed poorly leading to high overall energy consumption. Furthermore, use of codes as targets doesn't allow for flexibility to allow building owners and managers to select the most cost-effective EE technologies to achieve EBEE targets (SECSC 2013, 59-60).

Activity 3: Estimate the Costs and Impacts of the Program

The next component of Changning District's EBEE targets and improvement program development included estimating the costs and impacts of each target-setting approach. The summary results of different approaches described above are presented in Table 5. In terms of implementation costs per unit of floor area, the current building codes approach required the lowest cost per m^2 (RMB 120/m^2 or US$17.39/$m^2$); while the overall ranking method required the highest cost per m^2 (RMB 456/m^2 or US$66.09/$m^2$). In terms of total energy savings, the top runner target-setting method had the highest energy savings of 48,020 TCE; and the building codes approach had the lowest energy savings of 33,438

[23] U.S. EPA's ENERGY STAR® PortfolioManager® tool can be accessed at https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager

TCE. Since the normalized target-setting method was only applied to 68 of the 100 buildings in Hongqiao ETDZ, its estimated savings only equated to 17,152 TCE. For an equitable comparison to the other approaches, it was recommended that Changning District apply this method to all 100 buildings in Hongqiao ETDZ (SECSC 2013, 58-59).

Table 5. Summary of Benchmarking Approaches for Building Consumption

Approaches		# of buildings	Total floor space ($10^6 m^2$)	Total energy consumption(10^3TCE)	Potential for Retrofit				
					Investment (10^6 US$)	Savings (10^3TCE)	Investment per TCE saved (10^3US$)	Investment per m^2(US$)	% of savings
Energy Consumption per m^2	Overall Ranking	28	1.24	98.0	82.04	35.3	2.32	66.09	36.0
	Categorized Ranking	56	2.45	134.5	86.67	36.2	2.39	35.36	26.9
	Advanced Benchmarking	64	2.81	154.5	117.12	48.0	2.43	41.74	31.1
	Normalized Benchmarking	43	1.64	100.5	37.71	17.2	2.22	23.33	17.1
Approach Based on National Building Codes		90	3.57	172.45	62.29	33.4	1.80	17.39	20.3

Source: SECSC 2013, 59.

Activity 4: Determine on Which Buildings the Program Will Be Implemented

As a result of this analysis, and in consultation with experts, Changning District determined that it would utilize methodology 2d (Normalized Target-Setting) to both select buildings and establish energy savings targets for those buildings in order to meet the district's overall energy savings goal of 33,000 TCE saved (SECSC 2013, 10-11). The selected buildings (type and number) and the total and percentage energy savings targeted for each building in Hongqiao Demonstration Area is shown in Table 6 below (EFC(a) 2012, 17).

Table 6. 33,000 TCE Energy Saving Breakdown Table

Existing Building Type		**Amount**	**Total Energy Savings TCE)**		**Percentage of Energy Savings**
Hotel	Five-star	13	1577.9	2876.5	9%
	Four-star		956.0		
	Three-star and below		342.6		
Shopping Mall		7	8410.6		25%

Commercial Office Building	48	10572.2	32%
Government Office Building	6	982.5	3%
Mix-used Commercial Building	7	7284.7	22%
Other	19	2873.4	9%
Total	100	33000	100%

Source: EFC(a) 2012, 17.

2.2 Develop Locally Appropriate Policy, Building on National, Regional, or Global Models

Activity 1: Develop Policy Options

Changning District evaluated a range of practical and implementable incentives and disincentives to promote stakeholder buy-in of its overall EBEE targets and improvement program (SECSC 2013, 15). A mapping of these measures by stakeholder group in Changning District is presented in Table 7. This is not a comprehensive list, but an illustration of the various options explored by the district. Table 7 shows that different measures are more appropriate for different stakeholders, which makes it critical for the government to consult with all the key stakeholders when designing any incentives and disincentives to facilitate buy-in of policies.

Table 7. Possible Incentives and Disincentives by Stakeholders

Generic Incentives/Disincentives		Stakeholders						
		Owners	Retrofit Developers/ESCOs	Financial Institutions	Renters	Government Agencies in Charge of Retrofit Permits	Municipal Government	Government Service Occupants
Incentives	Grant	X					X	
	Technical Assistance and Education	X	X	X	X	X	X	X
	Green Performance Award	X			X		X	X
	Low Interest Loan/Line of Credit		X	X			X	
	Rebate	X			X		X	X
	Tax Incentive	X	X					
	Permit Process Incentive	X	X			X		
Disincentives	Administrative and Failure to Perform Fines	X					X	
	Higher Utility Rate/Surcharge	X			X			
	Name and Shame List	X					X	

Source: SECSC 2013, 62.

As a result of this analysis, in January 2013, Changning District developed a new policy, the *Management Method of the Special Funds for Low-Carbon Development in Shanghai Changning District* – which could be valid for five years. This policy's subsidies related to building EBEE improvement included the following:

Table 8. Management Method of the Special Funds for Low-Carbon Development in Shanghai Changning District Policy Description

Policy	**Description**
Existing Building EE Retrofit Projects Subsidy for Demonstration Projects	This provides a subsidy based on energy saved/investment of 1000 RMB/TCE (US$144.93/TCE) saved. If the building performance improved significantly, a subsidy of 25% of the EE retrofit is provided. This provides a subsidy of 20,000 to 25,000 RMB (US$2,898.55/TCE to US$3,623.19/TCE) per project
Subsidy for Interrupted Operation from a Retrofit	This subsidizes 30% of the total rental cost loss, if the retrofit takes six months or more. There is a ceiling of RMB 1 million (US$0.14 million) per project.
Subsidies for Fundamental Work to Build the Low-Carbon Demonstration Area	This includes a subsidy to establish a building energy data on-line monitoring system; a subsidy for assessment and evaluation; a subsidy for low-carbon research; and a subsidy of RMB 1000 per TCE (US$144.93/TCE) for other low carbon projects in the Low-Carbon Demonstration Area.

Source: SECSC 2013, 12-13.

Changning District also determined that more studies would be needed to calculate the level of additional subsidies needed to reduce the long payback period (e.g. 8-10 years) of many deep energy savings retrofit projects to the level that institutional investors are willing to finance (e.g. 3-5 years). The additional subsidy types included: subsidies for EE technologies with long pay-back period; and additional subsidies for savings and investments made by building owners and managers.

In addition to financial incentives, Changning District determined that non-financial incentives were equally important to implementing a successful EBEE targets and improvement program. Such incentives helped to shorten the building retrofit permit process and provided technical assistance to building owners, manages, and ESCOs through a low-carbon service platform that offered support for:

- Estimating energy and cost saving potential
- Targeting EE improvement measures
- Conducting energy audits
- Accessing financing
- Measuring and verifying energy savings (SECSC 2013, 13-14)

2.3 Adopt Policy

Activity 1: Set EBEE Targets by Building Type

As described above in section "Develop A: Activity 4: Determine on Which Buildings the Program Will Be Implemented," Changning District determined that it would utilize methodology 2d (Normalized Target-Setting) to both select buildings and establish energy savings targets for those buildings in order to meet the district's overall energy savings goal of 33,000 TCE saved. The selected buildings (type and number)

and the total and percentage energy savings targeted for each building in Hongqiao ETDZ is shown in Table 9 below (EFC(a) 2012, 17).

Table 9. 33,000 TCE Energy Saving Breakdown Table

ECB type		**Amount**	**Total energy savings (TCE)**		**Percentage of energy savings**
Hotel	Five-star	13	1577.9	2876.5	9%
	Four-star		956.0		
	Three-star and below		342.6		
Shopping Mall		7	8410.6		25%
Commercial Office Building		48	10572.2		32%
Government Office Building		6	982.5		3%
Mix-used Commercial Building		7	7284.7		22%
Other		19	2873.4		9%
Total		100	33000		100%

Source: EFC(a) 2012, 17

Changning District decomposed the total energy saving target (the 33,000 TCE) to different ECB types for retrofit in Table 9. The breakdown was based on the identification of each ECB type's retrofit baseline. The process for Changning to perform this work is shown in Figure 12 below (EFC(a) 2012, 15).

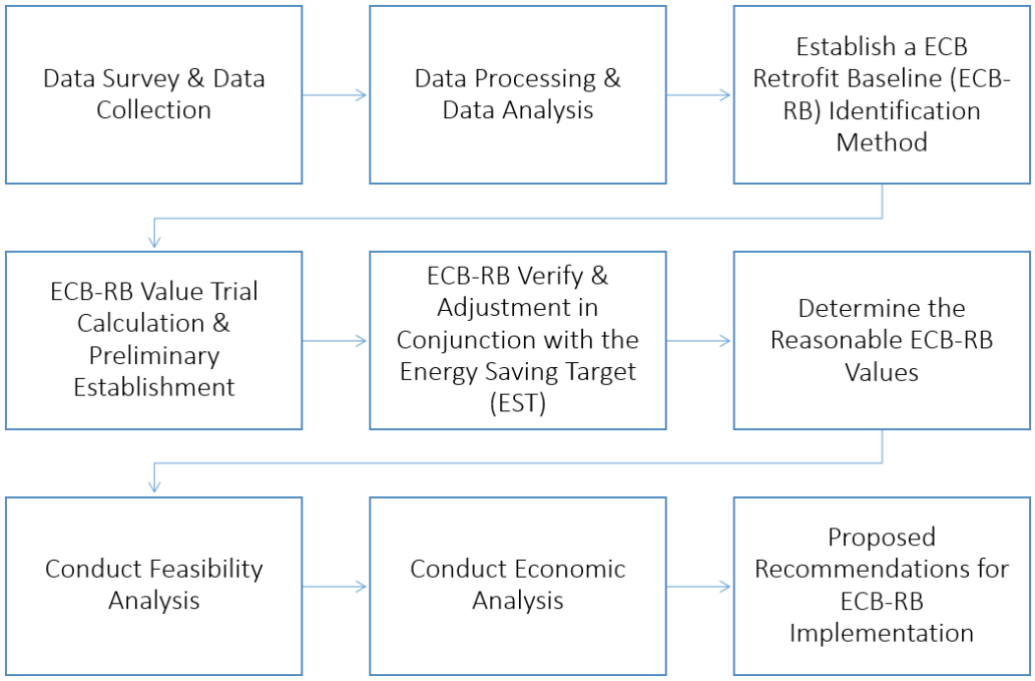

Figure 12. Process to identify the retrofit baseline for different EB types for breakdown the energy saving target.

Source: EFC(a) 2012, 15.

Activity 2: Select Policies to Facilitate the EBEE Targets and Improvement Program

Changning District also adopted the following energy conservation and emissions reductions requirements; management measures; financial incentives; and reward measures to facilitate its EBEE targets and improvement program.

Energy Conservation and Emission Reduction Requirements

Public buildings in Changning District include the following types: public institutes, hotels, shopping centers, commercial buildings, and multi-functional buildings (shopping center and commercial office). Energy conservation and emission reduction requirements were divided into two levels as follows:

- ***"Guide on Rational Use of Energy in Shanghai***. Energy consumption of all starred hotels, government office buildings, and large-scale commercial buildings in Changning District shall meet the requirements of the *Guide on Rational Use of Energy in Shanghai*. If the buildings mentioned above cannot meet the requirements of the Guide, energy conservation management shall be strengthened, a building retrofit plan shall be developed, and energy conservation measures shall be implemented. Rational use of energy indicators of starred hotels, government office buildings, and large-scale commercial buildings in Changning District are defined.
- ***National Requirements on Building Energy Conservation.*** According to the *Notice on Further Advance the Public Building EE*, issued by the MOHURD and MOF, the energy consumption per unit building area of public buildings shall be reduced 20% by the end of the 12th FYP (30% shall be reduced for large-scale public buildings)" (SECSC 2013, 63).

Management Measures

- ***"General Management Measures***
  - ***Energy Conservation Supervision Management***. The energy conservation department of the Changning District government shall strengthen energy conservation supervision management, push forward relevant agencies to fulfill their energy conservation responsibilities regulated in National Energy Conservation Law, strengthen statistics on energy consumption, execute an energy consumption reporting system, implement energy audits, develop building retrofit plans, take energy conservation measures, and improve energy use efficiency.
  - ***Energy Saving Target Assessment*.** Owners of public building in Changning District shall set energy conservation and emission reduction targets for the 12th Five Year period, and annual energy conservation targets. Changning District Development and Reform Commission shall conduct annual assessments.
  - ***Energy Consumption Display*.** According to annual assessment results of public buildings energy conservation targets, Changning District shall display energy consumption level and energy conservation target implementation status of those public buildings that cannot reach their energy conservation target.
  - ***Forbid to Use Eliminated Energy-using Equipment*.** Eliminate energy-using equipment and techniques that are forbidden to be used in public buildings according to Ministry of Industry Information and Technology (MIIT's) Phase-out List of Energy Intensity & Laggard Mechanical and Electrical Equipment and Product, and Phase-out List of Laggard Production Capability, Techniques, and Products" (SECSC 2013, 63-64).

- ***"Management Measures on Public Agency***
  - ***Energy Consumption Measurement.*** Building energy consumption sub-meter systems shall be implemented in public agencies. Energy consumption shall be measured separately according to energy type and energy-use system. Energy consumption monitoring and measurement management shall be strengthened.
  - ***Implement Energy Consumption Quota System*.** The national energy consumption quota system shall be strictly implemented.
  - ***Energy Efficient Product Purchase.*** Take precedence to use of products listed in the Government Procurement of Energy Efficient Product List.
  - ***Budget Evaluation.*** The implementation status of the energy conservation target shall be integrated into the financial budget system, and the energy consumption budget shall be checked according to the respective energy consumption quota.
  - ***Responsible Person's Appraisal****.* Principals of public agencies shall be responsible for the energy conservation management of his/her agency. Energy conservation target implementation status shall be a content of evaluation on public agency principals' performance" (SECSC 2013, 64).
- ***"Management Measures on National Invested Public Buildings***
  - ***Responsible Person's Appraisal****.* The energy conservation target implementation status of the state-owned public buildings in Changning District shall be integrated into the target responsibility system management evaluation system. Respective rewards and punishments shall be implemented. If a public building cannot pass the evaluation, the principal's name shall be circulated in a notice of criticism" (SECSC 2013, 64).

Incentive Policies for Building Retrofit

The target group of buildings incentive policies implementation included the buildings where actual energy use intensity was relatively low, lower than the target value for EE improvement, but the energy saving potential was still high (SECSC 2013, 64).

Financial Support

Changning District arranged some special funds from its managed funds for energy conservation and emission reduction to support existing public buildings retrofit. This included those funds released through the *Management Method of the Special Funds for Low-Carbon Development in Shanghai Changning District* on December 28, 2012 (SECSC 2013, 65).

- ***"Support for Prophase of Building Retrofit***
  - ***Energy Audit*.** The subsidy for energy audits implemented by public building with energy consumption is over 2,000 TSC per year shall be less than 80,000 RMB (US$11,594.20); public building where energy consumption is 500 to 2,000 TSC per year shall be less than 40,000 RMB (US$5,797.10). Buildings which implement energy audits in 2012 and 2013 shall be provided full subsidy equal to the actual audit fee; the percentage of subsidy shall be reduced gradually in future years.
    - Subsidy to establish the building energy data on-line monitoring system maintenance (service purchase).
    - Subsidy for purchasing out-source assessments, evaluation, and other expertise.

        - Subsidy for low carbon development research projects, capacity building, etc.

- ***Support on Owner and Property Manager for Building Retrofit***
    - ***Building Integrated Renovation Project.*** 20% of actual energy conservation investment shall be subsidized, and the subsidy for a single building shall be less than 2 million RMB (US$0.29 million). The subsidy shall be 50% of the difference between non-depreciation values of transformed equipment and actual retained earnings. Further, the newly released *Special Fund* for Changning District provides subsidies for energy efficiency retrofit projects based on energy saved. The Fund provides RMB 1000/TCE (US$144.93/TCE) saved to projects for which energy saving can reach more than 50 TCE or equivalent CO_2 emission reduction. And, if the building performance gets improved significantly through the project, the subsidy will cover 25% of EE retrofit investment.
- ***Single Energy Conservation Technology Transformation Project***[24]
    - ***Energy Intensity Equipment Transformation***. Existing public buildings related to boiler and elevator energy conservation transformation shall be subsidized according to the EE rate. Coal fired boiler alternative projects shall be subsidized 120,000 RMB per steam ton (US$17,391.30 per steam ton).
    - ***Exterior Wall, Window, and Shading Transformation***. Existing public buildings related to window, door, and shading shall be subsidized according to a certain rate of the whole investment.
    - ***Air Conditioner System and Lighting System Transformation*****.** Air conditioner system and lighting system transformation shall be subsidized according to the amount of energy saving, a maximum amount of subsidy for air conditioner system and lighting system is set separately. The *Special Fund* for Changning District also provides financial support for the envelope retrofit projects and green outdoor lighting retrofit projects. The subsidy amount is reviewed by District DRC and related agencies, and requires approval from the District Government.
    - ***Renewable Energy Application***. The subsidy for solar energy application shall be subsidized according to the beneficial area per m^2 of the collector area. The subsidy for solar PV power generation systems shall be subsidized according to the installed capacity, and the maximum amount of subsidy for one unit shall not be over certain amount. The annual renewable energy replacement quantity of a building could be deducted from its annual comprehensive energy consumption. The new released Changning District *Special Fund* also supports the development of distribution energy generation systems and renewable energy projects. The fund provides a subsidy of 20% of the investment, and the ceiling amount is 3 million RMB (US$0.43 million) per project. The annual energy production of the renewable energy projects should not be less than 100 TCE.
    - ***Roof Greening*****.** Roof greening construction and maintenance for existing public institutions shall be integrated into the department financial budget; Changning District government shall provide a subsidy to roof greening and vertical greening according to the area" (SECSC 2013, 65-67).

[24] Changning implemented subsidy for "Building Integrated Renovation Project" very well and that maximized the energy savings with a limited financial support. Thus, subsidies for the single technologies were not actually implemented in Changning.

- ***"Contract Energy Management Projects*** The subsidy for a contract energy management project shall be according to the energy saving amount. The subsidy standard is 500 RMB per TSC (US$72.46/TSC), and 15% of actual energy conservation investment shall be provided in a one-off subsidy manner. Projects which have acquired municipal special incentive funds shall be matched 1:1 by Changning District. The subsidy for one single project shall not be over 2 million RMB (US$0.29 million) in total. Pilot projects which could meet over 55% requirements of the existing buildings retrofit standard, with one single public building area over 20,000 m^2, the subsidy shall be provided by per m^2 of construction area. This subsidy cannot apply with the other subsidies at the same time" (SECSC 2013, 67).
- ***"Management of Differences on Support Funds between Upper Government and Changning District.*** If there are already some national and municipal funding support and incentive policies, the building retrofit projects mentioned above which shall be provided subsidy by Changning District shall apply for national and municipal support and subsidy first. If the subsidy from the state and municipal government is lower than the funding standard of the Changning District, the differences shall be provided by the Changning District government. The *Special Fund* also provides co-funding for projects which receive national or municipal funding support. Changning District will also provide subsidies based on the energy saved, including a 20,000-250,000 RMB (US$2,898.55-36,231.88) reward for demonstration projects" (SECSC 2013, 67).
- ***"Continue Subsidy for Promoting Energy Efficient Product Policy***
  - *Energy Efficient Lighting.* The scope of Shanghai municipal government financial subsidy on EE lights is as follows: when selecting EE product suppliers through open tender and signing supply agreements, the subsidy shall be provided to the project unit as 30% of the negotiated rate. Product categories include: CFLs, three primary double end fluorescent lamps (T8, T5), metal halide lamps, high voltage sodium lamp, and light-emitting diodes (LED).
  - *Energy-Efficient Air Conditioner*. According to the subsidy standard regulated in the Implementation Rules on Promoting Energy-Efficient Air Conditioners for Energy Conservation and Being Beneficial to People Project, issued by MOF, National Development and Reform Commission (NDRC), and MIIT, Changning District shall provide district subsidies, through district government finance, after the expiration of the promotion period(June 1st, 2013)" (SECSC 2016, 67-68).
- ***"Subsidy for Business Interruption.*** If the business interruption period caused by comprehensive building retrofit is over 6 months, Changning District shall provide a certain amount of subsidy to compensate for rental loss caused by building retrofit. The Changning District *Special Fund* will also provide the subsidy of 30% of the total rental cost loss if the retrofit takes six months or more, to compensate the interrupted operation due to a retrofit. The subsidy ceiling is RMB 1 million (US$0.14 million) per project.
- ***Subsidy for Projects of special Important Effect*.** For building retrofit projects of special important effect, like exterior wall transformation, the subsidy shall be provided on a 'one case, one method' manner.
- ***Evaluation on Building Retrofit Projects not Reach Target.*** For building retrofit projects that do not reach the target, the subsidy shall be deducted by a certain percentage according to actual investment" (SECSC 2013, 68).

Reward Measures

- ***"Reward for Building Retrofit Demonstration Project.*** Projects which adopt energy efficient building envelope, renewable energy, or new technologies, and could save energy by 55% after retrofit, shall be rewarded no more than 250,000 RMB (US$36,231.88) after being reviewed and evaluated as Changning District building retrofit demonstration projects.
- ***Reward for Advanced Agency and Personnel***. Departments of Changning District, energy use units, and property managers shall be rewarded if they have outstanding achievements on promoting building retrofit, energy conservation management, and energy consumption reduction. Further, the *Special Fund* provides a subsidy of RMB 20,000 to 250,000 (US$2,898.55-36,231.88) for each demonstration project, or to the outstanding personnel, as the encouragement and reward" (SECSC 2013, 68).

Some other incentive policies included preferential tax (for either Owner/Property Management Retrofit, or Contract Energy Management Project) and financing support (for example, some energy conservation and emission reduction special funds were set up to encourage commercial banks to issue loans to ESCOs for EBEE projects) were also considered in Changning District at the beginning of the program. To cities which have better relevant context, these policy instruments are highly recommended to consider to integrate into their EBEE program policy system (Mao 2019).

Develop D: Develop Implementation Plan

Activity 1: Develop an Implementation Plan and Timeframe

To achieve its goal to reduce energy consumption in 100 existing building in the Hongqiao ETDZ by 18%, equivalent to 33,000 TCE, Changning District adopted a three-phase implementation plan as follows:

- Phase I – focuses on improving EE in the buildings where actual EUI is higher than the target value. They represent large energy saving potential that can be achieved at lower cost (e.g., operational improvements, lighting retrofits).
- Phase II – focuses on improving EE in buildings where actual EUI is higher than the target value. They represent large energy saving potential that can be achieved at higher cost (e.g., envelop retrofit).
- Phase III – focuses on buildings where actual EUI is higher than the target value, but the actual energy saving potential is small (SECSC 2013, 62).

Changning District also constructed a time series plan for the EBEE targets and improvement program based on the World Bank project duration of five years (5 years) and marketing cycle[25] theory as follows:

- Single EBEE cycle = marketing cycle + theoretical construction period.
- All of the 100 EBEE projects needed to be completed within the World Bank's five-year (60-month) project.
- With the Building Energy Efficiency Project Implementation Plan – Computer Aided Tool (PIP-CAT), Figure 13 shows the decision and implementation timeframe for implementing EE improvements in each of the 100 buildings in the Hongqiao ETDZ under the dual conditions of incentives and disincentives in Changning District (EFC(b) 2012, 22).

[25] "Marketing cycle" refers to the time from the start of negotiations to the signing of the contract.

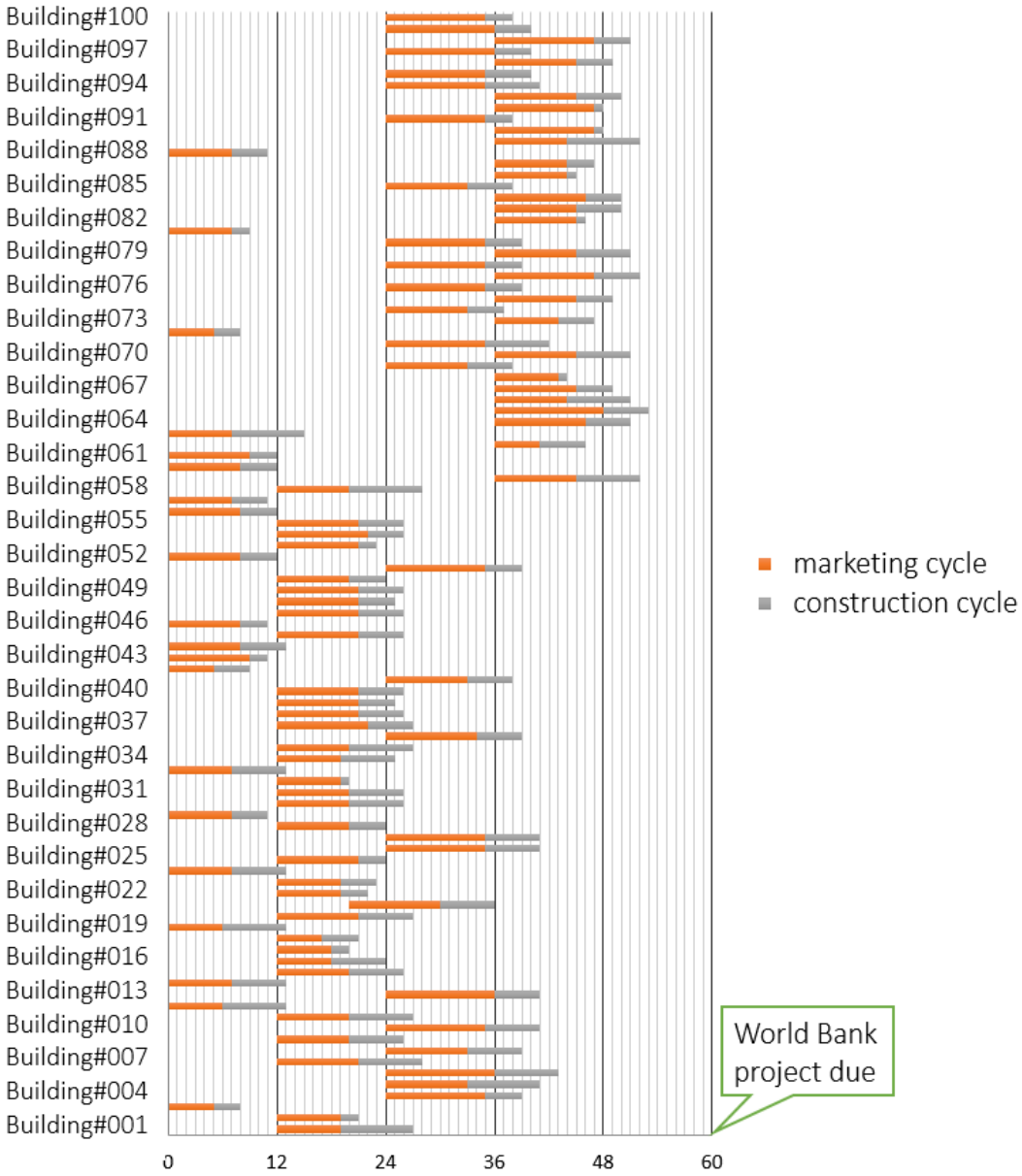

Figure 13. EBEE improvement decision and implementation timeframes for 100 buildings under the dual conditions of incentives and constraint. Source: EFC(b) 2012, 22.

III. IMPLEMENT

3.1 Implement Energy Savings Actions

Activity 1: Analysis on Possible Problems might exist during the Implementation Process of the EBEE Program

With a specialized management agency, URLCPMC, in charge of Changning District's EBEE Program, Changning District sought to avoid a number of potential problems that could arise during the EBEE targets and improvement program implementation process. During the implementation process of the EBEE program, URLCPMC provided refined incentive policies, financial explanations, feasibility analyses, and some other professional services. When compared with the traditional model, URLCPMC was capable of solving three possible and critical problems (described in Table 10) and simultaneously improving the management system and mechanism for promoting low-carbon work (SABR 2019, 17-18).

Table 10. Comparison of Specialized Management Institutions and Traditional Models

Possible problems	**Specialized management institutions model**	**Traditional models**
Problem 1- Uncertainty of the owner's return on investment	• Method - Policy and financial explanations. • Effect - Help owners understanding the return on investment of the project and make quick judgments. • Process - Organizing experts to perform evaluation during energy diagnosis process.	• Method - Measured by the owners or third parties. • Effect - The calculation results are not comprehensive enough for specialized management organizations.
Problem 2- Both parties of the retrofit do not trust the project cost, technology, and effectiveness	• Method - Expert review system. • Effect - In the perspective of fair and authoritative third parties, the retrofit plan and results will be evaluated to eliminate the mistrust of the owners and service companies. • Process - Organizing experts to perform evaluation during remodeling process.	• Method - The third-party service company communicates with the owner individually. • Effect - There is still a problem of mistrust between the owner and the service company.
Problem 3- Is it possible to get financial subsidies?	• Method - Pre-trial filing system. • Effect - At the beginning of the retrofit project, the two parties carried out the identification of the retrofit project content, technology, energy saving rate and management requirements, and ensured that the subsidy was successfully obtained in the later stage of the project. • Process - Filing acceptance.	• Method - Apply for subsidies after the project is completed. • Effect - Many projects did not meet the subsidy requirements and lost the subsidy.

Source: SABR 2019, 17-18

Activity 2: Develop Project Management Processes for the EBEE Program

In Changning District, the URLCPMC implemented a detailed project management process, shown in Figure 14, to provide comprehensive support to the building owners participating in the EBEE Targets and Improvement Program (SABR 2019, 19). Within the project management processes, main stakeholders

were all included with a clear role. Each procedure might involve more than one party, and each party might participate in multiple different procedures.

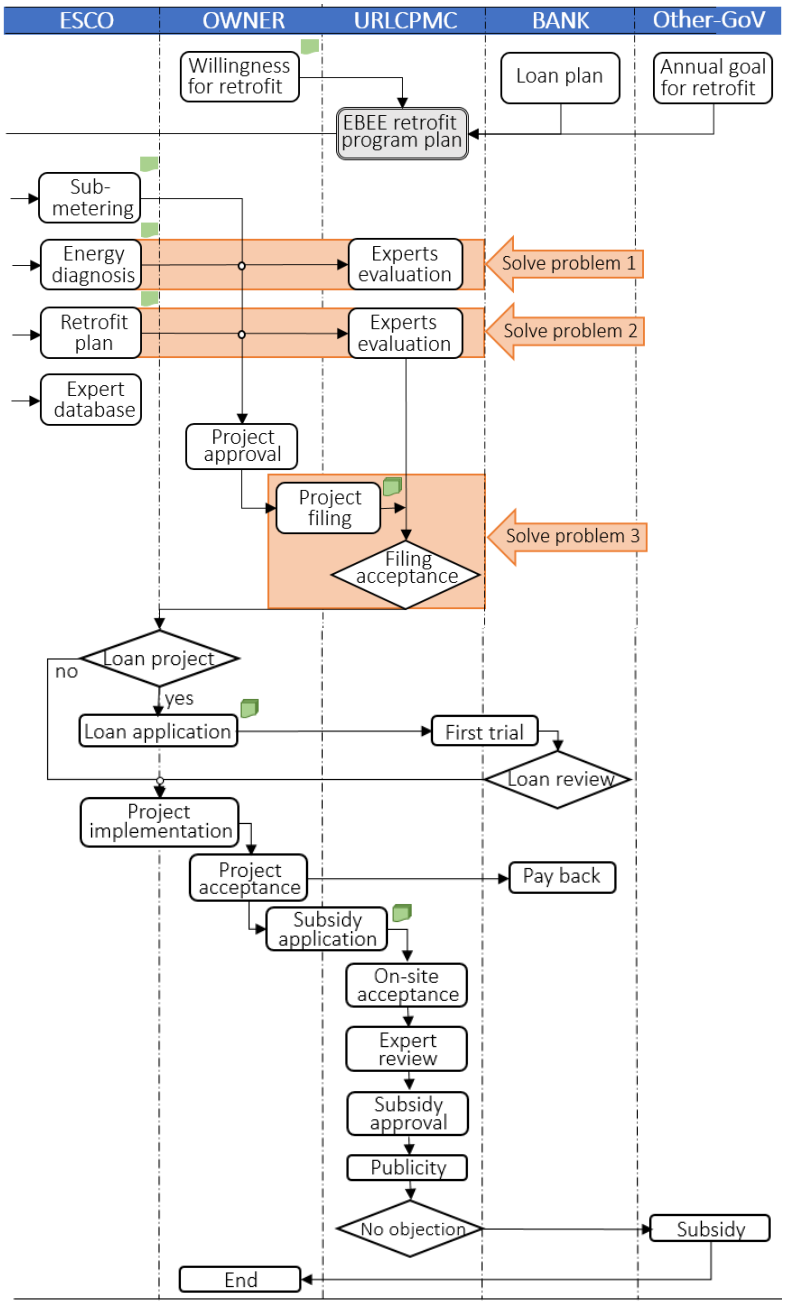

Figure 14. EBEE Project Management Process Implemented by Professional Management Agency – URLCPMC.

Source: SABR 2019, 19.

Implement B: Monitor Progress and Make Adjustments, Taking Immediate Action to Resolve Problems that Arise

Activity 1: Monitor Progress

Changning District selected a few key performance indicators (KPI) to measure and evaluate the progress of its EBEE targets and improvement program. The KPIs include the following:

- Number of buildings implemented retrofit
- Total floor area implemented retrofit
- Energy savings realized through retrofit
- Energy savings rate realized through retrofit
- Total CO_2 emission reduction through retrofit
- Total subsidies approved to the retrofit projects
- Percentage of the target achieved

Within the KPIs above, URLCPMC of Changning District implemented the EBEE program and reviewed the progress periodically. Given that the EBEE improvement projects were easily influenced by a lot of exterior factors which were out of anyone's control, it was hard to conduct an annual progress review. Thus, Changning District adopted a flexible progress monitoring method, which combined the EBEE program's progress assessment with the World Bank project's requirement of a phased assessment, or when either Shanghai municipalities or Changning Government required (EFC(a) 2012).

Activity 2: Build Feedback Mechanisms to Resolve Problems that Arise

The URLCPMC of Changning District also paid great attention to the effectiveness of relevant technologies and policy effects in its EBEE targets and improvement program. They continually optimized and improved the technology solution and policy system on the basis of feedback mechanisms so that technologies and policies could better meet the actual needs of the market (SABR 2019, 20). As shown in Figure 15, the URLCPMC of Changning District set up a technical effect feedback mechanism to identify excellent energy-saving technologies, research new technologies, and guide owners and third parties to adopt appropriate technologies.

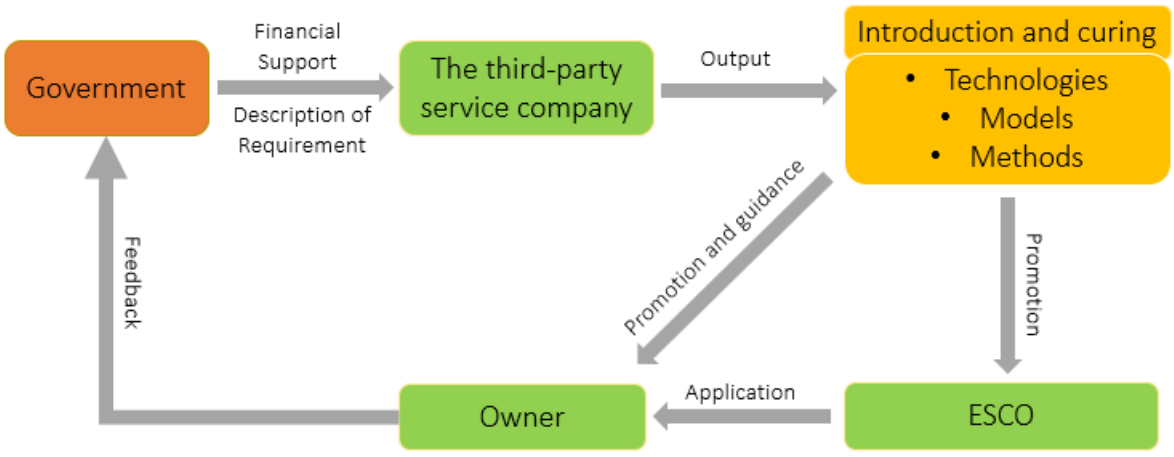

Figure 15. Technical effect feedback mechanism in Changning District. Source: SABR 2019, 20.

The URLCPMC of Changning District also paid attention to the policy effects. It evaluated the implementation effect of the EBEE retrofit policies issued by the government, provided policy opinions and suggestions, and influenced the optimization and improvement of government policies (Figure 16).

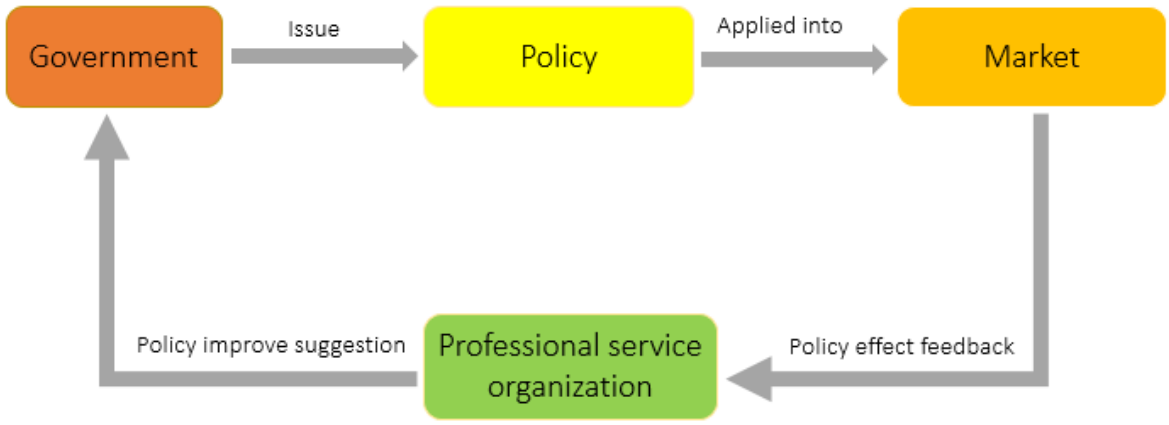

Figure 16. Policy effect feedback mechanism in Changning District. Source: SABR 2019, 20.

Implement C: Showcase Results to Stakeholders and the Public

Activity 1: Showcase to Stakeholders

Changning District implemented the EBEE improvement projects in phases as outlined in the implementation plan. During the implementation of the program, Changning District took comprehensive measures to promote the EBEE targets and improvement program. In the end, significant achievements were realized as follows (SABR 2019):

- A total of 45 existing buildings completed, with a total floor area of 2.87 million m2, completed energy efficiency upgrades.
- Total energy savings were equivalent to 31,233 TSC.26
- Emissions of 63,285 tons of CO2 was avoided (SABR 2019).
- A total number of 18 buildings were subsidized by the Shanghai Changning District government with a total subsidy of 27.095 million RMB (US$3.93 million)27
- (SABR 2019).

Activity 2: Public What Results have been Achieved

The URLCPMC of Changning District participated in the "Second Sino-US Climate Smart/ Low Carbon City Summit," "Central Asia Regional Economic Cooperation Program - Low Carbon City Development International Forum," and the "International Energy Efficiency Partnership Organization Energy Efficiency Financing Working Group Technical Seminar," and established contacts with Asian banks, C40, and other international organizations to share the valuable experiences of its EBEE targets and improvement

[26] The energy saving here is calculated with energy savings in each building's EE plan, not an actual measured value.
[27] Because the payment of subsidies to each EE project was delayed, the final actual subsidy is more than this figure.

program. In China, professional forums, demonstration project brochures, promotion videos, and energy-efficiency trainings were held, and excellent cases of the Changning District's project were introduced to expand the impact of the Project (Figure 17).

(a) Changning promotion video

(b) Demonstration project brochure

(c) Final summary meeting

(d) Final summary meeting report

(e) C40 China building program signing ceremony

(f) China-US low carbon city summit live speech

Figure 17. Policy effect feedback mechanism in Changning District. *Source:* SABR 2019, 21.

IV. IMPROVE

Improve A: Review and Evaluate Implementation, Impacts, and Potential

Activity 1: Continually Extend and Improve the ECMP

As described in Figure 2 in section "Assess A - Activity 3: Assess Available Data," Changning District completed its first ECMP and officially put it into operation in July 2011. At that time, Changning's ECMP covered 100 commercial buildings, or 63% of commercial buildings, within the district.

With the promotion of the EBEE targets and improvement program, 187 commercial buildings were added to the ECMP, effectively covering more than 95% of the large commercial buildings[28] and state office buildings in the region. Besides adding new buildings to the ECMP, Changning also extended and upgraded the ECMP's multiple functions[29] and made the ECMP support not only available to governments but also other relevant stakeholders (Figure 18 and 19) (SABR 2019, 47-55).

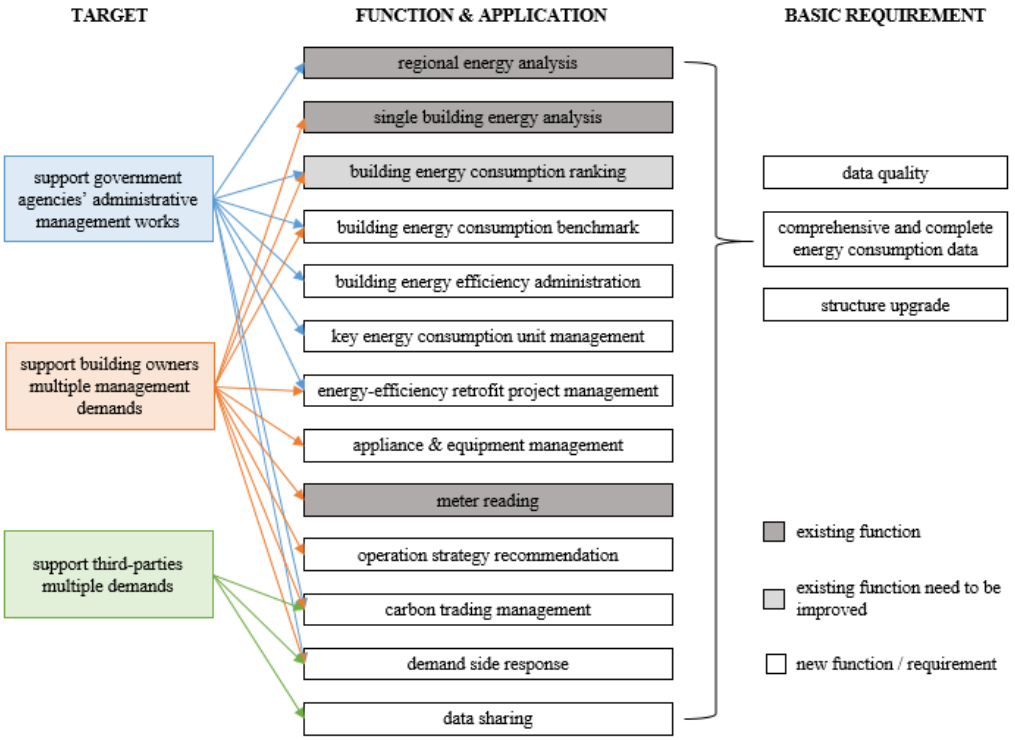

Figure 18. Top-level design structure diagram of ECMP in Changning in 2016. *Source:* SABR 2019, 48.

[28] Large commercial building refers to commercial buildings with a single building area of over 20,000 m2 and has a central HAVC system.

[29] The function "carbon trading management" was removed later with a few adjustments to ECMP in Changning.

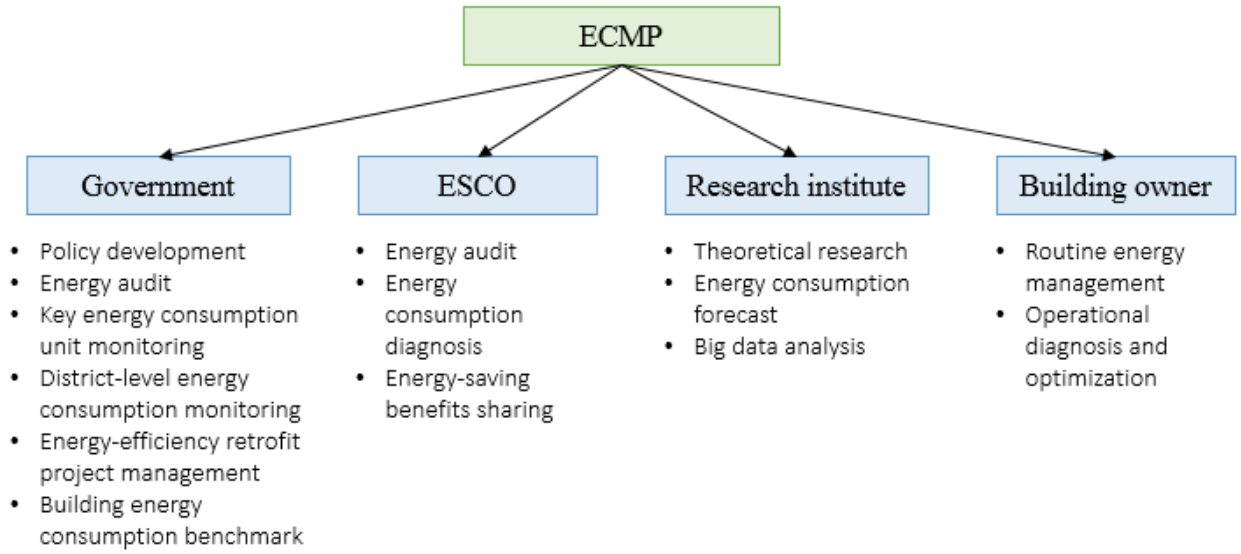

Figure 19. Top-level design structure diagram of ECMP in Changning in 2016. *Source:* SABR 2019, 48.

The current platform is in the leading position in Shanghai and even China in terms of functional innovation, data accuracy and wide application. It has led the construction of ECMPs in various districts in Shanghai and exceeded the platform construction planned indicators of this project.

During the promotion of the project, the platform not only provided strong data support for the government to define the goal orientation of low-carbon construction, formulate classification policies and conduct process supervision, and promoted the government's transformation to a refined management model. It also provided an effective tool for building owners and ESCOs to strengthen energy management, explore energy-saving and emission reduction potentials, achieve commercial cooperation, promote building energy efficiency improvement and market-oriented promotion of energy-saving and emission-reducing services, etc. As the platform data continues to accumulate, the architecture modules continue to be upgraded, and the depth and breadth of applications continue to expand, the platform will continue to provide long-term services and support for the construction of low-carbon cities in Changning and Shanghai.

Activity 2: Update the CO_2 abatement Cost Curve based on Real Data

As shown in Figure 6 in section "Assess B: Understand Benefits and Potential Barriers," Changning District developed a CO_2 abatement cost curve showing abatement potentials, costs, and ease of implementation for various CO_2 abatement options, at the very beginning of the program. The cost curve allowed the Changning District government to make an informed decision about targets and to identify priority actions – such as improving EBEE (World Bank 2013). As the EBEE targets and improvement program progressed, and more and more local data became available (including building types, technologies, costs and energy savings, payback period, etc.), Changning District continually updated its cost curves to include more accurate data to provide better guidance to EBEE projects in the area, and also to provide valuable references for other cities in China and worldwide (Figure 20) (SABR 2019).

Besides the cost curves, Changning District and Shanghai also analyzed financial internal rate of return (FIRR) of different technologies adopted by upgraded buildings by type. The 100 upgraded buildings in Changning achieved a high average energy saving rate at 22.19%, and the average FIRR was up to 20.48% (SABR 2019). These metrics provide valuable benchmarks for cities globally as to the potential savings for EBEE targets and improvement programs.

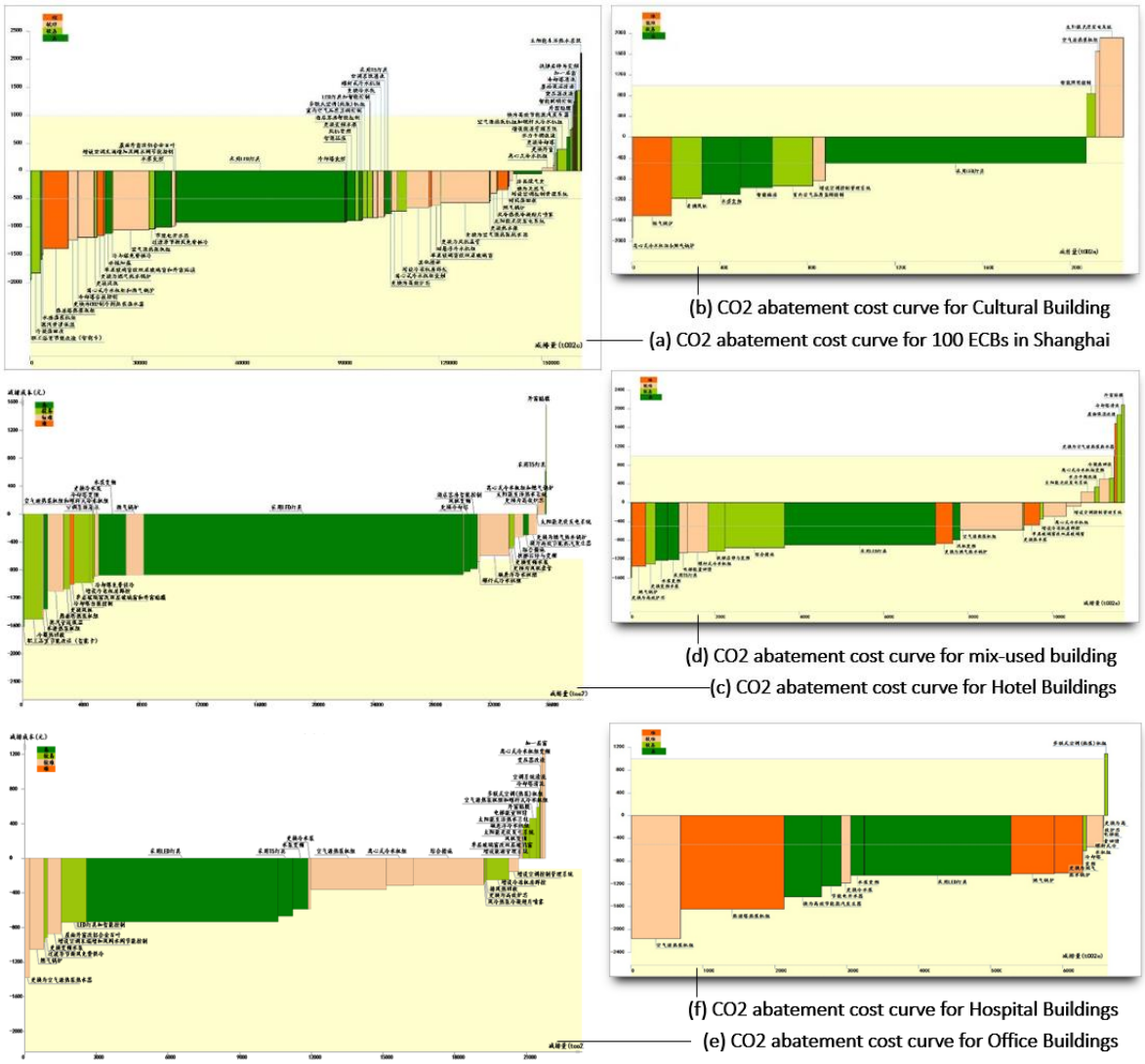

Figure 20. A set of updated CO_2 abatement cost curves for Shanghai and Changning. *Source*: SABR 2019, 48.

Improve B: Analyze Evaluation Results and Assess Next Steps

The EBEE targets and improvement program in Changning District not only brought significant energy-saving and emission-reducing benefits, but also introduced a set of internationally advanced project management methods and mechanisms to the district. For next steps, through the use of various energy-

saving technologies in the Changning District, a number of additional EBEE improvement projects will be implemented in the district, and transformation modes and mechanisms will further be explored.

Based on the accumulated experiences and data, one of Changning District's partners, the East China Architectural Design Institute (ECADI), developed an EBEE optimization tool for its customers in Shanghai (Figure 14) which can help other districts in Shanghai replicate Changning's success. It integrates five functions including the following:

- Energy consumption status assessment and diagnosis
- EE technology introduction and display
- EE retrofit planning and optimization
- CO_2 abatement cost curve
- Case database (Mao 2019)

Figure 21. A set of updated CO_2 abatement cost curves for Shanghai and Changning *Source:* Mao 2019.

With the availability of such tools, the complexities and difficulties of implementing similar large-scale EBEE targets and improvement programs, or a single EBEE improvement project, can be reduced to a great extent. Scaling up become possible and easier.

References

Bai, W. 2007. *Study of Civil Buildings Energy Demand and Environment Load*. Beijing: Tongji University.

Becque, R., E. Mackres, J. Layke, N. Aden, S. Liu, K. Managan, C. Nesler, S. Mazur-Stommen, K. Petrichenko, P. Graham. 2016. *Accelerating Building Efficiency: Eight Actions for Urban Leaders*. Washington, DC: World Resources Institute Ross Center for Sustainable Cities.

BPIE (Building Performance Institute Europe). 2019. *How to Include Building Renovation in Your Sustainable Energy and Climate Action Plan: Ensuring Ambitious Local and National Building Renovation Policy*. Brussels, Belgium: BPIE.

BPIE. 2020. "Long-Term Renovation Strategies and Local Building Renovation Initiatives: Case Studies from 8 Countries." http://bpie.eu/publication/long-term-renovation-strategies-and-local-building-renovation-initiatives-case-studies-from-8-countries/

Burr, A., C. Majersik, and N. Zigelbaum. 2013. *The Future of Building Energy Rating and Disclosure Mandates: What Europe Can Learn from the United States.* Washington, DC: Institute for Market Transformation and Natural Resources Defense Council.

C40 Cities. 2018. *Using Data for Policy: A Manual for C40 Cities.* London, United Kingdom: C40 Cities.

C40 Cities, Burohappold Engineering, and Rockwool. 2020. "Case Studies and Results." https://c40.my.salesforce.com/sfc/p/#36000001Enhz/a/1Q000000MpLD/WFMffl4QGu5znTk1ngLCeB3e7nHHsGd8iS4lo.lJj9k

Chen, X. 2014. "Application of Sub-metering Data Based on Energy Consumption Monitoring Platform." *Architectural Energy Conservation* (8): 86-92. DOI: 10.3969/j.issn.1673-7237.2014.08.020.

EFC(a) (Energy Foundation China). 2012. *Study on the Baseline of Existing Commercial Buildings Energy-Saving Renovation in Changning District, Shanghai*. Beijing, China: Energy Foundation China.

EFC(b). 2012. *Project Implementation Time Series Planning and Fund Schedule Research.* Beijing, China: Energy Foundation China.

Hou, J., Y. Liu, Y. Wu, N. Zhou, and F. Wei. 2016. "Comparative Study of Commercial Building Energy-Efficiency Retrofit Policies in Four Pilot Cities in China." *Energy Policy* 88 (C): 204-215. 10.1016/j.enpol.2015.10.016.

IOSM (Information Office of Shanghai Municipality Shanghai Municipal Statistics Bureau). 2018. *Shanghai Basic Facts 2018.* Shanghai: Zhongxi Book Company. http://www.shanghai.gov.cn/shanghai/node27118/fj/2018-ShanghaiBasicFacts.pdf

LBNL (Lawrence Berkeley National Laboratory). 2019. "BETTER: Building Efficiency Targeting Tool for Energy Retrofits (Alpha)." https://better.lbl.gov/.

Lee, S.H., T. Hong, M. Piette. 2015, S. Taylor-Lange. "Energy Retrofit Analysis Toolkits for Commercial Buildings: A Review." Energy 89: 1087-1100.

Mao Q., Deputy Director of Shanghai Changning District Urban Renewal and Low Carbon Project Management Center, pers. comm., April 3-4 and July 8, 2019.

Navigant Consulting, Inc., Steven Winter Associates, Inc., and Newport Partners, LLC. 2015. *New York City Benchmarking and Transparency Policy Impact Evaluation Report.* Washington, DC: U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. https://www.energy.gov/sites/prod/files/2015/05/f22/DOE%20New%20York%20City%20Benchmarking%20snd%20Transparency%20Policy%20Impact%20Evaluation....pdf

SABR (Shanghai Academy of Building Research). 2019. *Shanghai Low Carbon City Green Energy Project-Project Summary* Refinement (Final Report). Shanghai, China: SABR.

SECSC (Shanghai Energy Conservation Supervision Center) Government of Changning, and World Bank. 2013. "Policy Frameworks and Business Models for Building Retrofit in Changning District, Shanghai." Unpublished manuscript, last modified February 29, 2013.

Shanghai Highlights. 2019. "Shanghai Facts." https://www.shanghaihighlights.com/essential/.

Shanghai Statistical Yearbook. 2018. "Land Area, Population and Density of Population in Districts (2017)." http://www.stats-sh.gov.cn/tjnj/nje18.htm?d1=2018tjnje/E0202.htm

Sherlock, L., A. Armstrong, G. Joly, E. Kelleher, F. Wei, N. Zhou, H. Lu, X. Liu, J. Ge, J. Hou, X. Wang. 2018. *China Building Programme (CBP) Launch Report: Constructing a New, Low-Carbon Future.* London: C40.

Smart Energy Analytics Campaign. 2020. "EIS (Energy Information System). https://smart-energy-analytics.org/glossary/eis-energy-information-system.

Wikipedia. 2019. "Changning District." https://en.wikipedia.org/wiki/Changning_District.

World Bank. 2013. *Applying Abatement Cost Curve Methodology for Low-Carbon Strategy in Changning District, Shanghai.* Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/16710

World Bank. 2019. "Green Energy Schemes for Low-carbon City in Shanghai, China." http://projects.worldbank.org/P127035/green-energy-schemes-low-carbon-city-shanghai-china?lang=en

Wu Y., Director of China Association of Building Energy Efficiency, pers. comm., May 9, 2019.

Zhu J. and Q. Xu. 2016. "Operation and Management Practice of Shanghai Public Building Energy Consumption Monitoring Platform." *Construction Science and Technology* (4): 17-20. (in Chinese) DOI: 10.16116/j.cnki.jskj.2016.04.004

Appendix

I. For details about Changning's use of the "CO_2 Abatement Cost Curve Tool", please see: World Bank. 2013. *Applying Abatement Cost Curve Methodology for Low-Carbon Strategy in Changning District, Shanghai.* Washington, DC: World Bank.

https://openknowledge.worldbank.org/handle/10986/16710

II. For details about Changning's use of different "benchmarking methodologies," please see below:

SECSC (Shanghai Energy Conservation Supervision Center) Government of Changning, and World Bank. 2013. "Policy Frameworks and Business Models for Building Retrofit in Changning District, Shanghai." Unpublished manuscript, last modified February 29, 2013.

III. For cities in the European Union (EU), the "Clean Energy for All Europeans" package is a comprehensive set of legislation that defines European climate and energy policy for beyond 2020 and can be a source of existing policies and programs. For building policies, on the national level, member states are required to prepare long-term renovation strategies (LTRS) to achieve a highly energy efficient and decarbonized building stock by 2050. Regional and local authorities also play a large role in leading and achieving climate initiatives, not only in drafting and implementing building policy, but often in implementing even more ambitious local targets. On the municipal level, voluntary signatories of the Covenant of Mayors are required to create their own policy and framework to achieve climate goals, called Sustainable Energy and Climate Action Plans (SECAP). The buildings sector is one of the main sectors covered under SECAPs. Table 2 below provides some building policies and programs for EU members states.

Table 2. EU Countries and Building Policies and Programs

Country	Building Policies and Programs
Turkey	• Izmir has committed to reduce its carbon footprint by 20% by 2020 while Bursa has targeted a >40% reduction in per capita CO_2 emissions by 2030. Both municipalities aim to reduce energy consumption by improving efficiency in existing buildings. • Eskişehir aims to renovate multiple districts by improving energy efficiency in buildings and public spaces. It strives to adopt and implement laws that are more ambitious than national building codes and to use energy performance contracting to retrofit municipal buildings.
Spain	• Zaragoza Vivienda has promoted building renovations since 1989 and is now developing a 2030 Municipal Rehabilitation Action Plan. • Txantrea district in Pamplona supports deep energy renovation in buildings by developing energy saving measures and renewable energy heating systems. • Extremadura plans to renovate 705 public buildings by 2030.
Poland	• The Silesian region's SPACE initiative supports the implementation of solutions to reduce emissions and consumption of environmental resources, including public facilities. • Wroclaw is renovating the district of Nadodrze, known for its historic buildings. With a budget of €14 million Nadorze's buildings are being renovated.
Italy	• Lombardy created the Regional Fund for Energy Efficiency (FREE). The fund helps municipalities renovate public buildings towards Nearly Zero energy level. From 2014-2020, the fund had a budget of €11.710.348,02.

	• Milan allocated €22,250,000 to improve the energy efficiency of private and public buildings focusing on deep renovation in December 2019.
Croatia	• ZagEE (the Zagreb Energy Efficient City project) supports energy efficiency measures in the facilities owned by the City of Zagreb. It has financed the renovation of 3 city government buildings, 15 primary schools, 7 high schools, 36 kindergartens, 6 homes for the elderly, 3 health centers and 17 local government buildings.

Source: BPIE 2020.