BUILDINGS ENERGY EFFICIENCY CONSORTIUM

U.S. - CHINA CLEAN ENERGY RESEARCH CENTER (CERC-BEE)

YEAR 4 JOINT ANNUAL MEETING

Berkeley California

#F1: Research on Very Low-Energy Building Operations and Management Methods

U.S. and China Research Lead(s): ICF International (ICF), Sustainable Energy Partnerships (SEP), and Ministry of Housing and Urban-Rural Development (MOHURD), Center of Science and Technology of Construction (CSTC)

U.S. and China Industry Partner(s): US-China Energy Cooperation Program (ECP)

Presented By

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Background and Context

- Energy consumption in residential and commercial buildings accounted for over 40% of primary energy use in the US in 2012, and over 25% in China in 2011.[1]

- By working together the US and China can take advantage of our combined expertise to reduce energy use in buildings and promote low carbon development.

1 *Comparative Policy Study of Green Buildings in U.S. and China*, April 2014 by China Energy Group, Lawrence Berkeley National Laboratory and Qing Ye, Shenzhen Institute of Building Research

What China Needs

- **Rapid Urbanization –** China's commercial building stock is estimated at 43 billion m^2, five times the size of the US, and growing at 2 billion m^2 annually *(=21 new Empire State Buildings added per day!)*

- **Energy and Carbon Targets** – In the 12th Five Year, China aims to reduce energy use intensity by 16%, and approximately 17% of these reductions (or 0.97 billion kilowatt-hours) should be a result of improvements to building energy efficiency.

- **Low Energy Efficiency Existing Buildings** – For instance, in Beijing, building energy consumption is currently still twice as high as major cities in in Northern Europe.

- According to China Academy of Building Research (CABR), a leading institute of China's Ministry of Housing and Urban-Rural Development (MOHURD), "***In order to meet its national energy and carbon reduction targets, China needs a standardized methodology to benchmark energy performance of buildings, and it needs effective policy measures to supervise and improve buildings' energy efficiency at the operational stage***." *(Feb 2014)*

What the US Needs

- US companies are among the largest suppliers of green building technologies in the world. They need tools to assist in selling technologies into **China's US$ 45 billion clean energy market (the largest in the world).**

- **US policymakers need to improve the efficiency and reliability of national-level building energy data collection** and to evolve codes, standards, and policies in response to new market conditions.

- The US can learn from China's **investment in real-time, on-line building energy monitoring**, as well as policy innovations, such as **integration of the buildings sector into the national Emissions Trading Scheme (ETS)**.

- **Both countries need to establish robust national building energy databases**. While country attributes are unique, countries benefit from collaboration. The US and China have expressed interest in collaboration on build-out and use of the Standard Energy Efficiency Data (SEED) platform across their countries. **This may be an area for further co-investment going forward.**

Project #F1: Purpose and Objective

- **Drive very low-energy buildings in China and the US through collaboration on:**
  - **Building Energy Performance Database, Rating System, and Policy/Program Framework Development**
    - A benchmarking tool (and associated energy database and policy) for China will drive US technology sales and reductions in existing building energy use in China – key objectives of both countries.
  - **An Evaluation and Energy Reporting Protocol for CERC Demonstration Buildings:**
    - Provides consistent and transparent performance information to US and Chinese CERC leadership in order to evaluate the performance of the demonstration buildings.
    - Results needed to validate US and Chinese investment in CERC.
  - **Joint Research and Lessons-sharing on Innovative US and Chinese Building Energy Policies, such as:**
    - Application of real-time, on-line, energy monitoring to increase efficiency and reliability of data collection
    - Innovative building energy policies
      - ETS for public buildings in China
      - Advancement of SEED platform in the US

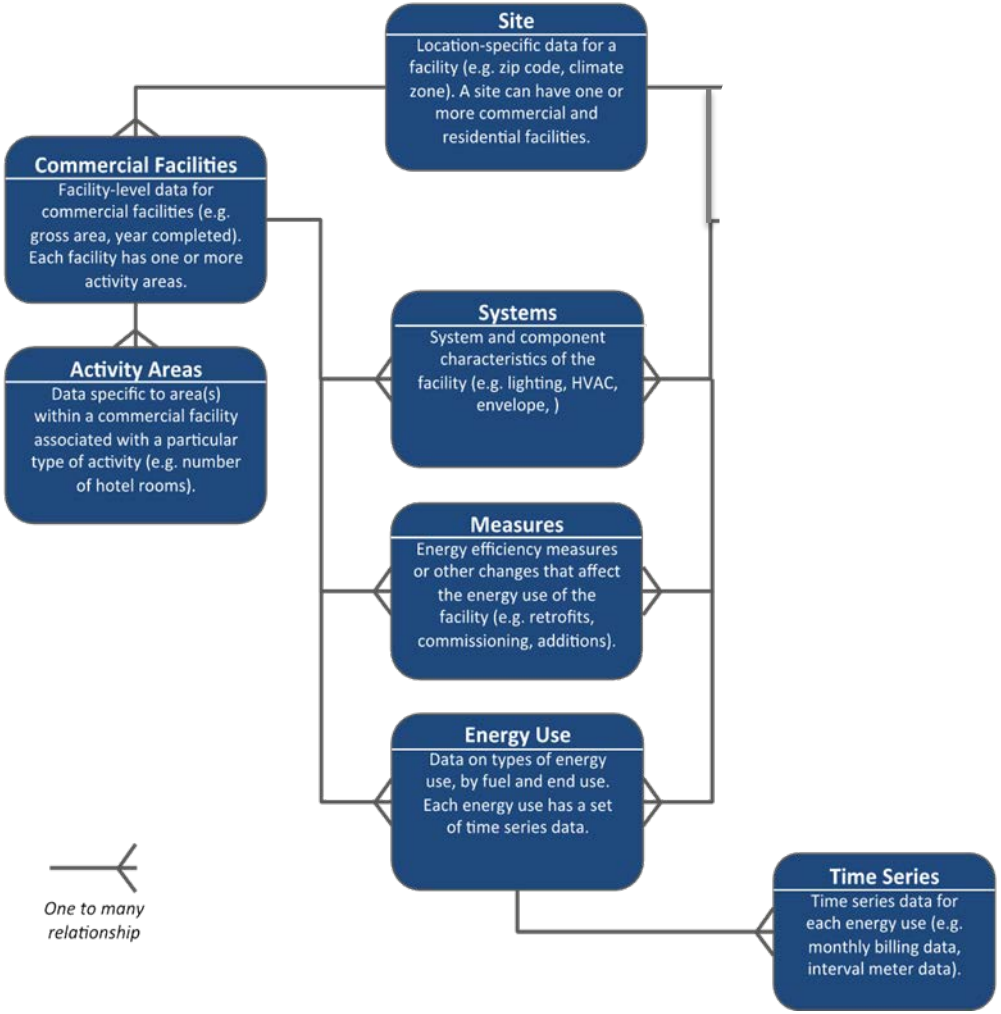
Progress and Accomplishments on Year 4 Milestones

Task 1: Develop and Pilot National Building Energy Performance Benchmarking Tool, Database, and Policy Framework

	Target Outcomes	Progress Against Outcomes
H1 FY2014 (Mar – Aug)	▪ **Draft commercial building energy performance database taxonomy for China (Completed)**	▪ **CSTC has completed a draft national-level hotel energy characteristics database**. ▪ Draws on **US Department of Energy (DOE) Building Performance Database (BPD) taxonomy.** ▪ Initial data sourced by **ICF, CABR, Tsinghua, and CST**C. ▪ Includes energy usage, energy management, envelope and structure, general building information, and other points needed for benchmarking for more than **750 hotels in China, across multiple cities**. ▪ Further work will focus on leveraging **the SEED platform. SEED is free, open-source software application. Source code will be posted on-line in several weeks, and advances options for US-China bilateral cooperation on this.** ▪ CSTC's Hao Bin is in coordination with both **LBNL and ICF** on leveraging DOE tools like SEED . **ICF in close coordination with DOE BTO.**
	▪ **Draft prototype Excel-based building energy performance benchmarking tool for China (Completed)**	▪ Established broad working group to focus on benchmarking tool development for China, including **CSTC, ICF, Tsinghua, and CABR**. ▪ Conducted **monthly working group sessions** to discuss various methods for benchmarking and to identify appropriate methodology for China. ▪ **Completed a revised (Version 2.0) prototype benchmarking tool** for Chinese hotels, based on ENERGY STAR methodology (but with appropriate customizations for China).

Outcomes: Task 1 Develop and Pilot National Building Energy Performance Benchmarking Tool, Database, and Policy Framework

DOE BPD Taxonomy Scheme for Commercial Facilities – Basis for CSTC Database



Ver. 2.0 China Hotel Energy Performance Benchmarking Tool Interface

Progress and Accomplishments on Year 4 Milestones

Task 2: Evaluation and Energy Reporting Protocol

	Target Outcomes	Progress Against Outcomes
H1 FY2014 (Mar-Aug)	▪ **Draft Evaluation and Energy Reporting Protocol. (Completed)** ▪ **Draft data collection template and other collateral to support implementation of the Evaluation and Energy Reporting Protocol. (Completed)** ▪ **Draft Evaluation and Energy Reporting Protocol reviewed by MOHURD and DOE. (In Progress)**	▪ Submitted **draft of Evaluation and Energy Reporting Protocol and Template to CSTC** for comments (29 May 2014). ▪ Received comments from CSTC (6 June 2014). ▪ Developed **revised Evaluation and Energy Reporting Protocol and Template** based on feedback from CSTC (15 July 2014). ▪ Delivered high-level introduction on **Evaluation and Energy Reporting Protocol to CERC developers** at Zhuhai Workshop on July 18th 2014. ▪ **Draft Evaluation and Energy Reporting Protocol and Template being reviewed by LBNL**, prior to being shared with US DOE (24 July 2014 to present). ▪ Presentation on **Draft Evaluation and Energy Reporting Protocol at CERC Annual Review Meeting (26 Aug 2014).**

Outcomes: Task 2 Evaluation and Energy Reporting Protocol

Key Elements

- **Element 1**: Calculation of Expected Energy Performance
- **Element 2**: Calculation of Post Occupancy Energy Performance
- **Element 3**: For applicable buildings, benchmarking using the *CERC China Building Performance Benchmark Tool.*
- **Building Boundaries**
- **Indoor Air Quality**
- **Occupant behavior, etc.**

Data Collection Template

CERC BEE Zero-Energy Demonstration Building Energy Data Collection Template- 1. Building Information

1-Buildings only need fill-in the cells in white color.

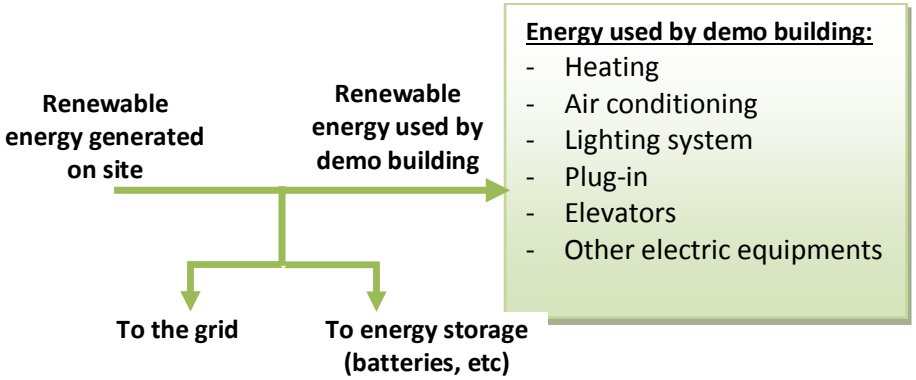
2-The cells in brown color are automatically calculated, no need to edit until it is necessary to change accroding to building stituation. In that case, building can edit and upate it.

1. Building Information							
Reporting Period (starting to ending) (MM/YYYY to MM/YYYY)							
Contact Person Information							
Name		*Title/Position*		*Email*		*Phone Number*	
Building Information							
Building name							
Building location (City & Province)							
Address & Zip code							
Year built				*Month and Year of first occupancy*			
Number of floors							
Self-generation electricity? (yes/no)				*If yes, what the technology? (e.g. PV, wind?)*			
Total building gross floor area (m^2)		*Office floorspace (m2)*		*Data center floorspace (m2)*		*Laboratory floorspace (m2)*	
		Restaurant floorspace (m2)		*Retail floorspace (m2)*		*Floorspace of fully-enclosed (or underground)*	

Chinese Standards Referenced

- China Standard for Building Energy Performance Certification (JGJ/T288-2012)
- Classification and Presentation of Building Energy Use Data (JG/T 358-2012).
- Design Standard for Energy Efficiency of Public Buildings (GB 50189)

Building Boundaries for Reporting



Progress and Accomplishments on Year 4 Milestones

Task 3: Collaboration on Building Energy Performance Monitoring and Standards

	Target Outcomes	Progress Against Outcomes
H1 FY2014 (Mar-Aug)	▪ **Conduct research on:** ▪ **Real-time building energy monitoring in China;** ▪ **Innovations in building energy performance codes, standards, and policies in China.** **(Complete)** ▪ **Develop draft report/briefing for US DOE on China's real-time building energy monitoring and innovations in policies in China.** **(In Progress)**	▪ **Drafted questionnaire** to obtain updates on real-time building energy monitoring in China (May 2014). ▪ Received **updates from CSTC on real-time building energy monitoring** (June 2014). ▪ Received **updates from CABR on real-time building energy monitoring** (June 2014). ▪ Conducted **interviews with Tsinghua University's Professor Xia Jianjun on real-time energy monitoring in China** (July 2014). ▪ **Visited Tsinghua's laboratory** for real-time, on-line building energy performance monitoring (July 2014). ▪ Conducted **desk research on government policies in China supporting real-time energy monitoring** (August 2014). ▪ Conducted **interviews and desk research on China ETS pilots and integration of public buildings** (July/August 2014). ▪ **Draft report/briefing for US DOE** on real-time building energy monitoring, public building ETS pilots (August 2014)

Outcomes: Task 3 Collaboration on Building Energy Performance Monitoring and Standards

- Wanda Plaza Portfolio (40 commercial buildings).
- Hourly data on a 24-hour schedule for whole building and major systems (HVAC system, chillers, pumps, fans, elevators, public parking, etc.).
- Conducting trend analysis to identify unusual activity (e.g., spikes).
- Conducting comparative analysis (building versus building; system versus system; energy usage increases/decreases against prior periods).
- Identifying explanatory factors for energy performance.

FY14 H1: Key Year 4 Technical Achievement

- **Working Group involving CSTC, Tsinghua, CABR, and ICF** focused on benchmarking database, tool, and policy development.
- **Draft building energy database** for China that draws on the DOE BPD taxonomy.
- **Strong interest from CSTC and DOE for continued bilateral cooperation on SEED platform build-up and roll-out**. SEED open source code will be available soon on-line. MOHURD in a position to "leapfrog" DOE and use SEED as basis for Chinese database. Opportunities for future co-investment.
- **Draft benchmarking system** for China modeled after ENERGY STAR (with customizations for China).
- Perfect positioning for **full adoption of the CERC benchmarking tools and systems in China through World Bank project to pilot a China national methodology and guidelines on energy performance benchmarking and disclosure for large public and commercial buildings in China (led by CABR and ICF).**
- **US-China Energy Cooperation Program (ECP) and BOMA China** committed to leveraging benchmarking tool to **advance sale of energy efficiency technologies** through training for member companies.
- MOHURD CSTC committed to incorporating benchmarking into **China's 13th Five Year Plan**.
- **Draft Evaluation and Energy Reporting Protocol** which provides consistent and transparent performance information to CERC leadership in order to evaluate the performance of the demonstration buildings.
- **Progress on informing US DOE on China's real-time energy monitoring and integration of buildings sector into ETS**, to inform advancements in US codes, standards, and policies.

Projected Energy, CO_2, and US Technology Sale Impact

Projected Energy and CO_2 Impact in China

	Total m^2 Benchmarked (2%)	Total Savings from Benchmarked Buildings (kWh)	GHG Emission Reduction (MtCO2e)	Wind Turbines Installed
Short-term: 2016-2017 (2yr)	29,400,000	1,169,197,200	949,797	262
Med-term: 2016-2020 (5yr)	78,000,000	6,086,232,000	4,944,151	1,362
Long-term: 2016-2025 (10yr)	171,000,000	23,784,354,000	19,321,220	5,321

This assumes 2% of total hotel square meters (new and existing) benchmark annually for a total of 20% coverage over 10 years. We assume each building saves an average of 10% in energy usage through implementation of O&M improvements , which is shown to be achievable based on 10+ years of ICF experience in China.

Projected US Technology Sale Impact

	Total m^2 Investing in Technology (%)	Estimated Retrofit Cost Per Square Meter (USD)	Total Sales (USD)
Short-term: 2016-2017 (2yr)	1,470,000	$82.93	$121,904,883
Med-term: 2016-2020 (5yr)	3,900,000	$82.93	$323,427,000
Long-term: 2016-2025 (10yr)	8,550,000	$82.93	$709,051,500

This assumes 5% of benchmarked buildings will invest in new technologies at an estimated retrofit cost per square meter of 523.03 RMB ($82.93). Retrofit costs per square meter are estimated based on retrofit costs of lighting, space heating/cooling and advanced elevators from a solution proposal done by CABR, Feb 2012 – Energy Efficiency retrofit plan for China Southern Grid office building. These are roughly in-line with Urban Land November/December 2009 report citing hole building green retrofits can cost anywhere from $27 to $75 per square meter - https://www.esbnyc.com/documents/sustainability/uli_building_retro_fits.pdf

Schedule of Completion: Task 1 Develop and Pilot National Building Energy Performance Benchmarking Tool, Database, and Policy Framework

- **FY14 H2: Sep 2014-Feb 2015 (50% of cumulative FY14 DOE funds remaining)**
- **Q3 2014 (Sep-Nov) Select appropriate city/region for pilot implementation of database, rating system, and policy/program framework in late 2014 and 2015.**
  - Leverage CSTC connections with **Shenzhen Institute for Building Research and Shanghai Institute for Building Research**.
  - Dovetail a benchmarking pilot program with **China Emissions Trading Scheme (ETS)** pilots where public buildings involved (Shanghai, Beijing, Shenzhen, etc.)
  - Dovetail with **World Bank Energy Performance Benchmarking & Public Disclosure (EPB&PD) program in Beijing and Ningbo**, led by CABR and ICF.
- **Q4 2014 (Dec-Feb) Initiate pilot of final commercial building energy performance data taxonomy for one city.**
- **Q4 2014 (Dec-Feb) Develop a final Excel-based prototype building energy performance rating system/tool for one commercial (public) building space types in China.**
- **Q4 2014 (Dec-Feb) Finalize draft framework for policies/programs that could integrate an energy performance database and rating system to deliver very low-energy buildings**
  - Draw on lessons of **New York City's Law 84**, NRDC's 2014 Benchmarking and Disclosure Policy Recommendations, **CSTC Energy Quota Standard,** etc.

Schedule of Completion Tasks 2: Evaluation and Energy Reporting Protocol

- Q3 2014 (Sep-Nov)
  - **Pilot the Evaluation and Energy Reporting Protocol**, including draft templates and training, **with the CABR demonstration building**.
  - Feedback obtained from CABR on the Evaluation and Energy Reporting Protocol.
- Q4 2014 (Dec-Feb)
  - **Workshop to introduce and train demonstration project developers** on the Evaluation and Energy Reporting Protocol.
  - **Final Evaluation and Energy Reporting Protocol**.
  - **Final template and training materials** to support the implementation of the Evaluation and Energy Reporting Protocol.

Schedule of Completion Task 3: Collaboration on Building Energy Performance Monitoring and Standards

- Q3 2014 (Sep-Nov)
  - Draft paper/briefing for US DOE on **China's real-time energy monitoring and innovations in building energy performance codes, standards, and policies** (e.g., integration of buildings sector into ETS).
    - *Focus on lessons and benefits for the US*
- Q4 2014 (Dec-Feb)
  - Final paper/briefing for US DOE on **China's real-time energy monitoring and innovations in building energy performance codes, standards, and policies** (e.g., integration of buildings sector into ETS).

Risks and Abatement

- **Risk 1: Lack of Relevance/Interest in US Benchmarking Tool and Database for China**
  - **World Bank and MOHURD's selection of ICF and CABR to deliver the World Bank Energy Performance Benchmarking & Disclosure in Large Public and Commercial Buildings Project**, is confirmation of Chinese government's long-term commitment to benchmarking, drawing on tools/approaches developed under the CERC program. It also ensures long-term sustainable impact of CERC benchmarking project.
  - **MOHURD is requesting additional collaboration around SEED platform and other DOE tools. (DOE is interested in engaging here).**
- **Risk 2: Lack of Benefits to the US**
  - The availability of a benchmarking tool has **significant potential to support sale of US technologies in China's US$ 45 billion clean energy market.**
  - **Both US and China need to establish robust national building energy databases.** MOHURD wants to know more about SEED and its application in China. DOE sees this as an area for future collaboration on build-out and roll-out, **as well as co-investment**.
  - **US policymakers are learning lessons from China's investment in real-time, on-line building energy monitoring, as well as integration of the buildings sector into the national ETS**. The US is benefitting from China's experience and perspective.

Appendix

Concept Proposal for Project Continuation: CERC FY 2015 (March 2015 to February 2016)

Proposed Budget: $100,000 to $125,000

- ***Task 1 – Building Energy Performance Database, Rating System, and Policy/Program Framework Development***
- Conduct training for green and energy-efficient building technology suppliers on utilizing building benchmarking system as sales tool to achieve US technology sales targets.(Q1-Q2 FY2015)
- Complete pilot of benchmarking policy/program in one city or region in China. (Q2-Q3 FY2015)
- Summarize findings/outcomes from the benchmarking policy/program framework and share with national policymakers at MOHURD in technical paper and workshop. (Q4 FY2015)
- Segue prototype benchmarking tool, database, and policy framework into **World Bank Energy Performance Benchmarking & Disclosure in Large Public and Commercial Buildings Project**, ensuring long-term sustainable impact of CERC benchmarking project. (Q4 FY2015)
- Impacts on CO_2 and US technology sales will begin in early 2016 (after pilot phase).
- ***Task 2 – Evaluation and Energy Reporting Protocol for CERC Demonstration Buildings***
- **Implement the Evaluation and Energy Reporting Protocol** for in all applicable demonstration buildings in 2015. This will involve ongoing monitoring and sharing of results with CERC leadership. (Q1-Q4 FY 2015)
- ***Task 3 – Collaboration on Building Energy Monitoring and Performance Standards***
- **Continue to identify lessons for US** from China's real-time energy monitoring and innovations in building energy performance codes, standards, and policies. (Q1-Q4 FY 2015)

Project Budget

Project Budget: $467,000 Total, Expended 87% To-Date ($ 408,109)

Additional Funding: $200,000 cost-share from USAID (2011-2012)

Year	Planned	Actual	Variance	Explanation
Year 1	$135,000	$135,000	$0	Work on target to develop benchmarking tools for China.
Year 2	$135,000	$150,000	+11%	Received budget increase due to importance/value of work.
Year 3	$135,000	$82,000	-39%	MOHURD priorities shifted to research methods on O&M, smaller budget allocated for more limited R&D SOW.
Year 4	$135,000	$100,000	-26%	MOHURD priorities shift back to benchmarking, smaller budget requested for more limited SOW with CSTC.
Year 5	$135,000	TBD	TBD	Original planned budget is $135,000. ICF requesting between $100K and $125K for Year 5.
Total	$675,000	$ 467,000		

Budget History					
FY2011– FY2013 (past)		FY2014 (current)		FY2015 (proposed)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$367,000	$200,000*	$100,000	TBD	$100-$125K	TBD

* Estimated cost-share from USAID US-China Sustainable Buildings Partnership in 2011 and 2012.

Project Plan and Schedule (Qtly)

Project Schedule		
Project Start: 1/1/2011		Completed Work
Projected End: 2/28/2016		Active Task (in progress work)
		Milestone/Deliverable (Originally Planned)
		Milestone/Deliverable (Actual)

	FY2014				FY2015			
Task	Q1 (Mar-May)	Q2 (Jun- Aug)	Q3 (Sep-Nov)	Q4 (Dec-Feb '15)	Q1 (Mar-May)	Q2 (Jun-Aug)	Q3 (Sep-Nov)	Q4 (Dec - Feb '16)
Past Work								
Q1 Milestone: Draft data taxonomy and tool								
Q2 Milestone: Draft demo building reporting protocol and policy briefing for DOE								
Current/Future Work								
Q3 Milestone: Draft benchmark policy framework; Pilot demo building reporting protocol with CABR demo building								
Q4 Milestone: Final taxonomy, tool, policy; Initiate pilot in select city; Roll-out building demo reporting protocol to developers; Finalize DOE policy briefing								
Q1 Milestone: Training for EE suppliers on benchmark; Ongoing implementation of demo reporting protocol; Ongoing policy/technology research for DOE								
Q2 Milestone: Ongoing benchmark pilot implementation; Ongoing implementation of demo reporting protocol; Ongoing policy/technology research for DOE								
Q3 Milestone: Complete pilot; Ongoing implementation of demo reporting protocol; Ongoing policy/technology research for DOE								
Q4 Milestone: Summarize outcomes from pilot and segue to World Bank project; Summarize outcomes from demo buildings; final policy/technology updates to DOE								

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