Executive Summary of Opportunity

Total Potential Savings

$603,000

Top Individual Potential Savings

<table>
<thead>
<tr>
<th>Building</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Park Place</td>
<td>290,000</td>
</tr>
<tr>
<td>Glencove Plaza</td>
<td>180,000</td>
</tr>
<tr>
<td>North Sail Building</td>
<td>90,000</td>
</tr>
<tr>
<td>Delway Building</td>
<td>33,000</td>
</tr>
<tr>
<td>Washington Plaza</td>
<td>10,000</td>
</tr>
</tbody>
</table>

Carolyn Szum, ccszum@lbl.gov
Lawrence Berkeley National Laboratory
Project Summary

Timeline:
Start date: April 1, 2016
Planned end date: March 31, 2021

Key Milestones:
1. Method for implementing outcome-based codes for US cities (FY17Q4)
2. Web-based Open-Source Building Energy Audit Tool (FY18Q4)
3. Systems Dynamics CERC-BEE Impact Model (FY19Q1)
4. Financial product for building energy efficiency piloted (FY19Q4)
5. Outcome requirements for US and Chinese model codes (FY20Q4)
* All milestone dates are based on CERC-BEE Fiscal Year (FY) which runs April 1 to March 31.

Budget:
Total Project $ to Date:
• DOE: $340,000
• Cost Share: $1 million
Total Project $:
• DOE: $1.94 million
• Cost Share: $6.89 million

Key Partners:

United States:
• Lawrence Berkeley National Laboratory (LBNL)
• Citi
• ICF International (ICF)
• Institute for Market Transformation (IMT)
• Johnson Controls, Inc. (JCI)
• Lutron Electronics, Inc.
• Natural Resources Defense Council (NRDC)
• New Buildings Institute (NBI)
• Rocky Mountain Institute (RMI)
• The Energy Foundation
• The Paulson Institute
• United Technologies Corporation (UTC) / United Technologies Research Center (UTRC)

China:
• China Ministry of Housing and Urban-Rural Development Center for Science and Technology of Construction (MOHURD CSTC)
• China Academy of Building Research (CABR)
• China Association of Building Energy Efficiency (CABEE)
• China State Construction Engineering and Corporation (CSCEC)
• Shanghai Pudong Development Bank (SPDB)
• Shenzhen Institute of Building Research (SZIBR)
• Tsinghua University

Project Outcome:
By 2025, save 6% annually of new and existing annual commercial and residential building energy usage1 and expand the global market for US building energy efficiency (EE) technologies by $60 billion annually by advancing: (1) outcome-based building energy codes; (2) system dynamics impact model; (3) data transparency policies and an open-source building energy audit tool; and (4) innovative financing mechanisms for building EE.

1. Percent maximum potential annual energy savings for each end use by 2025, (2010 base year).
Purpose and Objectives

Problem Statement:
US and China account for close to 40% of the global building energy use.

Barriers to Better Buildings:
- **New Buildings - Insufficient building codes:**
  - Do not address all factors of design, construction, and behavior that affect performance (plug and process loads) (MYP 163).

- **Existing Buildings – Insufficient data, tools, and financing:**
  - Lack of/asymmetric data (MYP 54, 75)
  - Lack of tools to efficiently and cost-effectively audit buildings at scale (MYP 54,74, 75).
  - Building EE is not considered an asset class (MYP 53, 74, 75).
  - Few models to test impact of national technology research and development (R&D) programs in US and China (MYP 103).

Target Market:
- Designers and developers of **new commercial** and **residential** buildings in the US and China.
- Owners, operators, tenants, energy service companies (ESCO), and financiers of **existing commercial building retrofits** in the US and China.
- National and local building energy **policymakers**.

Market Size:
Estimated Annual Energy Usage by 2025

*Business as Usual (2010 baseline)*

![Bar chart showing energy usage in Quads for USA and China from 2000 to 2030.](chart.png)
Outcomes and Impact

New Buildings (Near-Term):
- Outcome-based building codes that can ensure actual energy usage reduction for US and Chinese buildings.

Existing Buildings (Near-Term):
- Public data in US and China for retrofit identification, monitoring and verification (M&V), and policy development and evaluation, monitoring, and verification (EM&V).
- Cost-effective financial analyses and energy conservation measure (ECM) identification for buildings through a new open-source, web-based audit tool in US and China.
- Capital deployed at scale for building energy efficiency as a result of new, innovative financial products in US and China.
- A realistic model of technology and policy adoption to evaluate effectiveness of technology and R&D programs in the US and China.

Measurement Toward Performance Goals: CERC-BEE System Dynamics Impact Model (energy and CO₂); quarterly reporting.

Near-Term Outcomes (during project):
- Pilot demonstration.
- Tools and resources for scale-up.

Mid-Term Outcomes (1-3 years after project):
- Policy and tool adoption in 3 to 5 cities in the US and China.
- Observable innovations (i.e., audit tool software App for US and China).

Long-Term Outcomes (3+ years after project):
- National tool and policy adoption in the US and China (where applicable).
- 10+ cities applying:
  - outcome-based building energy codes
  - enhanced data transparency policies
  - audit tool
  - financial products for building EE

<table>
<thead>
<tr>
<th>2025 Annual Savings</th>
<th>US</th>
<th>China</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy savings (quads)</td>
<td>2.5</td>
<td>3.2</td>
<td>5.7</td>
</tr>
<tr>
<td>Percent savings (2010 base year)</td>
<td>6%</td>
<td>7%</td>
<td>13%</td>
</tr>
<tr>
<td>CO₂ reductions (MtCO₂)</td>
<td>240</td>
<td>300</td>
<td>540</td>
</tr>
</tbody>
</table>
Outcome-based Codes: Team, Approach, Outputs

**Partners, Subcontractors, and Collaborators**

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**FY16:** Research to assess prescriptive performance vs. “best practice” performance and the impact of operating conditions on outcome-based performance in China.

**FY17:** Develop Methodology for implementing outcome-based codes in US and Chinese cities (harmonized with prescriptive measures)
- Targets, enforcement, and compliance.
- Evaluate CERC-BEE demo buildings' potential outcome-based performance.

**FY18:** Pilot method for developing and implementing outcome-based codes in US and Chinese cities:
- New York City
- Shanghai

**FY19. Education and Training**

- Training curriculum, including case studies.
- Delivery to DOE, MOHURD, and US and Chinese cities (e.g., Washington, DC).

**FY20: New Standards**

- Outcome requirements for US model energy code and Chinese AEDG.
- Recommendations for DOE Asset Score.

**Outputs**

- **Publications:** 2 peer-reviewed papers / journal articles and 7 reports/guidebooks.
- **Training:** curriculum and delivery to 50 individuals.
- **Demonstrations:** Changning, Shanghai and New York City policy pilots.

**Distinctive Characteristics:**
- Lessons from China to US on code target-setting.
- Lessons from US to China on code implementation.

Timeline based on CERC-BEE Fiscal Year (Apr 1 – Mar 31)
Data Transparency and Impact Modeling: Team, Approach, Outputs

Partners, Subcontractors, and Collaborators

Distinctive Characteristics:
- Leverage current collaboration agreements and US-China bilateral platforms to emphasize both national and local level collaboration.
- Leverage IMT and NRDC to facilitate dissemination of pilot results and scale-up.

Outputs
- New standards: New data disclosure points for better retrofit identification, M&V, and EM&V integrated into US city policies and China national disclosure policy.
- Publications: 3 peer-reviewed papers / journal articles and 3 reports/guidebooks.
- Software: System Dynamics CERC-BEE Impact Model (open-source)
- Training: Curriculum and delivery to 100 individuals.
- Demonstrations: Shanghai, Washington, DC, and Cleveland, OH.

Timeline based on CERC-BEE Fiscal Year (Apr 1 – Mar 31)

FY16. Data disclosure points for better building energy retrofit identification.
  - Adapt Impact Model for CERC-BEE 2.0 and present to DOE on Impact Model framework assumptions and share best practices.

FY17. Data disclosure points for better building energy usage M&V.
  - Modify Impact Model to analyze the effect of demographic and economic factors on energy usage and CO₂ emissions.

FY18. Data disclosure points for better policy EM&V.
  - Perform policy scenario analysis using Impact Model and share results with DOE and MOHURD.

  - Washington, DC; Cleveland, OH; Shanghai
  - Final open-source Impact Model to DOE.

FY20. Quantify impact and disseminate results
  - CERC-BEE Impact Model
  - City Energy Project
  - MOHURD EPB&PD program.
Open-Source Audit Tool: Approach, Team, Outputs

**Partners, Subcontractors, and Collaborators**
- Berkeley Lab
- ICF
- Johnson Controls
- CABEE
- ITE
- Lab

**Distinctive Characteristics:**
- Emphasize building EE technology co-development; testing and demonstration in China and US; and scale-up in both countries.

**Key Issue:** Slower than anticipated collection of Chinese data for audit tool development.

FY16.

FY17. Audit tool source code published to GitHub

FY18.
Web-based audit tool in China.
- Evaluate opportunities to integrate with DOE Asset Score and ENERGY STAR Portfolio Manager.

FY19. Pilot projects
- Washington, DC
- Cleveland, OH
- Changning, Shanghai

FY20.
Incorporate in US and Chinese national and municipal programs:
- Commissioning
- Benchmarking

**Outputs**
- **New standards:** Audit tool incorporated into US and China national benchmarking policies and programs
- **Publications:** 1 peer-reviewed papers / journal articles and 4 reports/guidebooks.
- **Invention Disclosure:** 1st Joint US-China IPMP under CERC.
- **Copyrighted Software:** Building energy audit tool (open-source license agreement)
- **Training:** Curriculum and delivery to 100 individuals.
- **Demonstrations:** Changning, Shanghai, Washington, DC, and Cleveland, OH

Timeline based on CERC-BEE Fiscal Year (Apr 1 – Mar 31)
Financing: Approach, Team, and Outputs

Partners, Subcontractors, and Collaborators

Distinctive Characteristics:
- Leverage Chinese institutional capacity and willingness to invest heavily in financing policy development and deployment at national and sub-national level.
- US and Chinese bank financial product co-development.
- Partnership with Agricultural Bank of China (ABC) – the 4th largest bank in the world.


FY17. Develop program model:
- Sunshot-Catalyst
- Standardized EPC
- New credit information products
- G20 collaboration

FY18. Citi-IFC-ABC Pilot
- Specialized financial EE products
- "Green Finance" internet portal
- Case studies
- Information on leading-edge building EE technologies
- Training for bankers

Outputs
- **New standards**: ABC "greens" its banking business in China.
- **Publications**: 2 peer-reviewed papers / journal articles and 3 reports/guidebooks.
- **Workshops**: "Barriers and Solutions to Building Energy Efficiency Retrofits in China" US-China bilateral workshop.
- **Products**: Specialized EE financing product for ABC and Citi developed and piloted.
- **Training**: curriculum and delivery to 200 individuals.
- **Demonstrations**: Washington, DC? California? Wuhan, China?

FY19. City Retrofit/Financing Pilot Project
- Washington DC (?)
- California (?)
- Wuhan, China (?)

FY20. Tools and resources for scale-up

Timeline based on CERC-BEE Fiscal Year (Apr 1 – Mar 31)
Outcome-Based Codes: Progress and Accomplishments

Prescriptive Performance vs “Best Practice”

• Harmonized the prescriptive energy standard and the outcome-based standard by investigating Chinese prescriptive compliance performance and “the best practice” buildings achieved through improving unregulated measures and operating conditions (Shanghai climate zone).

<table>
<thead>
<tr>
<th>Performance (kwh/m²)</th>
<th>Prescriptive Baseline</th>
<th>Best practice</th>
<th>Outcome based required target</th>
<th>Outcome based Recommended target</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Government office</td>
<td>Commercial office</td>
</tr>
<tr>
<td>Small office (Cat A)</td>
<td>72.19</td>
<td>53.82</td>
<td>70</td>
<td>85</td>
</tr>
<tr>
<td>Large office (Cat B)</td>
<td>112.22</td>
<td>81.82</td>
<td>90</td>
<td>110</td>
</tr>
</tbody>
</table>

• Found that the recommended outcome-based target for large government office buildings is difficult to achieve.
• Other targets are achievable based on the prescriptive standards and changing operating conditions.
Outcome-Based Codes: Progress and Accomplishments

Operating Conditions Can Have Impacts on Outcome-Based Performance

<table>
<thead>
<tr>
<th></th>
<th>Beijing</th>
<th>Shanghai</th>
<th>Guangzhou</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Savings, kWh/m²</td>
<td>Savings ratio</td>
<td>Savings, kWh/m²</td>
</tr>
<tr>
<td>Small Office Building</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cooling setp</td>
<td>0.61</td>
<td>0.75%</td>
<td>0.81</td>
</tr>
<tr>
<td>heating setp</td>
<td>2.8</td>
<td>3.47%</td>
<td>2.98</td>
</tr>
<tr>
<td>lighting use</td>
<td>3.86</td>
<td>4.78%</td>
<td>4.12</td>
</tr>
<tr>
<td>equip use</td>
<td>6.27</td>
<td><strong>7.76%</strong></td>
<td>6.35</td>
</tr>
<tr>
<td>natural ventilation</td>
<td>1.01</td>
<td>1.25%</td>
<td>7.68</td>
</tr>
<tr>
<td>shading</td>
<td>0.2</td>
<td>0.25%</td>
<td>0.11</td>
</tr>
<tr>
<td>Large Office Building</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cooling setp</td>
<td>1.38</td>
<td>1.66%</td>
<td>11.86</td>
</tr>
<tr>
<td>heating setp</td>
<td>3.17</td>
<td>3.81%</td>
<td>3.58</td>
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<tr>
<td>lighting use</td>
<td>4.43</td>
<td><strong>5.33%</strong></td>
<td>7.23</td>
</tr>
<tr>
<td>equip use</td>
<td>7.17</td>
<td><strong>8.63%</strong></td>
<td>10.85</td>
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<tr>
<td>Natural Ventilation</td>
<td>10.71</td>
<td><strong>11.62%</strong></td>
<td>14.19</td>
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<tr>
<td>shading</td>
<td>0.77</td>
<td>0.93%</td>
<td>3.27</td>
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<td>economizer</td>
<td>0.34</td>
<td>0.41%</td>
<td>2.36</td>
</tr>
<tr>
<td>SA reset</td>
<td>1.15</td>
<td>1.38%</td>
<td>2.34</td>
</tr>
</tbody>
</table>

- **Communications:** 2017 ECEEE Summer Study Paper: *From Prescriptive to Outcome Based - the Evolution of Building Energy Codes and Standards in China.*
- **Next Steps:** (FY16) Finalize paper and deliver webinar to DOE on findings; (FY17) develop methodology for implementing outcome-based codes; (FY18) pilot in NYC and Shanghai; (FY19) training and tools for scale-up; (FY20) input into national model codes and guidelines in both countries.
Impact Model: Progress and Accomplishments

Impact Model Framework Complete

CERC-BEE System Dynamics Model

- A system dynamics simulation of building energy usage, disaggregated by climate zone, building type, end use, and end-use technology.
- Supports development of robust, effective policies optimized for their conditions in US or China.

Distinguishing Features

- Product and building turnover models, including a realistic model for product adoption.
- System dynamics permits dealing with complexity of behavior as well as complexity of detail.
- Models counter-intuitive effects like policy resistance.

Progress To-Date

- The model framework is complete, and ready to begin testing policy prototypes. The model has been calibrated to LBNL-RMI Reinventing Fire China.

Communications

- Preparing to present at International System Dynamics Conference, July 2017, Cambridge MA; preparing publication of model details.

Next Steps

- (FY16) Presentation to DOE to review framework assumptions and share best practices;
- (FY17) Modify and test the model to analyze the effect of demographic and economic factors on energy usage and CO₂ emissions;
- (FY18) Perform policy scenario analysis and share results with DOE and MOHURD;
- (FY19) Final, open-source Impact Model and usage guidelines for DOE and MOHURD;
- (FY20) Estimate impact of CERC-BEE program.
**Policy Opportunity 1:** Need for additional analysis of results, such as ECMs, financial analyses, references to government or utility incentives, etc. (Dunsky et al. 2009; Palmer and Walls 2015; Pan et al. 2016).

**Research Finding 1:** The minimum data points needed to generate these metrics are: monthly utility data, simple building characteristics (e.g., gross floor area, building type), and weather data.

### Data Transparency: Progress and Accomplishment

**Research Findings and Policy Recommendations**

<table>
<thead>
<tr>
<th>Tool</th>
<th>Building Performance Database (BPD)</th>
<th>C3 Commercial</th>
<th>Agilis Energy</th>
<th>FirstFuel</th>
<th>Chicago Loop Energy Retrofit Tool (Chicago area only)</th>
<th>HELIOS</th>
<th>Retrosynthesis</th>
<th>Consortium for Building Energy Innovation (CBEI)</th>
<th>Commercial Building Energy Saver (CBEES)</th>
<th>Customized Calculation Tool (CCT)</th>
<th>LEAN Energy Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tool Inputs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Accessibility for the public (Yes/No)</td>
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<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>a</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Utility Bills</td>
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<td>X</td>
<td>X</td>
<td>X</td>
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<td>Time Series Interval Energy Data</td>
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<td>X</td>
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<tr>
<td>Climate/Weather Data&lt;sup&gt;c&lt;/sup&gt;</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>a</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Simple Building Characteristics&lt;sup&gt;d&lt;/sup&gt;</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Detailed Building Characteristics&lt;sup&gt;e&lt;/sup&gt;</td>
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<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td><strong>Tool Outputs</strong></td>
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<td>Energy and Cost Savings Estimates</td>
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<td>Recommended ECMs</td>
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<tr>
<td>Benchmark Against Peers</td>
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<td>X</td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

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<sup>a</sup>Unknown; <sup>b</sup> Yearly source and site EUI; <sup>c</sup>A range of factors, including but not limited to, indication of climate zone, daily outdoor temperature, daily wet bulb temperature, heating degree day (HDD), cooling degree day (CDD); <sup>d</sup>Includes building type, vintage, floor area, occupancy density; <sup>e</sup> Goes beyond that listed in the simple category

Lee, Hong, and Piette 2015
Data Transparency: Progress and Accomplishment
Research Findings and Policy Recommendations

Policy Opportunity 2: Single building audits can be time-consuming and costly, and there is a need for greater standardization and automation (Hsu 2013; Kontokosta 2013; Pan et al. 2014)

Research Finding 2: Municipal audit programs cost 10X more than benchmarking and disclosure programs. NYC’s disclosure and benchmarking program costs $500-$1,500 per building. Auditing adds $1.50 per m². For 20,000 m² building, this is a cost of $30,000 (Hsu 2013, 266).

Policy Recommendation:
• Make public monthly energy usage data (broken down by fuel type).
• Develop a new, public, web-based, open-source retrofit analytical tools to screen for energy and cost savings opportunities and identify ECMs using the minimal amount of data possible (monthly utility bills, simple building characteristics, and weather data) for the US and China.


Next Steps: (FY16): Finalize ECEEE paper; summary report and webinar on disclosure data points for better retrofit identification to DOE, MOHURD, and key external stakeholders (NRDC, IMT, CABR, CEP, etc.); (FY17 and FY18) identify data disclosure points for better M&V and EM&V; (FY19) pilot new disclosure policies; (FY20) quantify impact of new disclosure policies and disseminate results in US and China.
Audit Tool: Progress and Accomplishments

- CERC 1.0 Benchmarking Tool being incorporated into Chinese national Code for Operation and Management of Central Air Conditioning System GB50365.

- First U.S.-China Joint IPMP drafted for the open-source audit tool.
  - A video showcasing the project is being developed.

- US-China open-source audit tool work plan under development.
  - Approach combines portions of JCI LEAN Tool with ASHRAE’s Inverse Modeling Toolkit to develop a new tool in Python.

- Communications:

- Next Steps: (FY16) Sign IPMP and develop preliminary database; (FY17) finalize database; develop audit tool source code in Python and publish on GitHub; (FY18) develop web-based tool in China; evaluate opportunities for integration with US tools; (FY19) pilot projects in US and China; (FY20) incorporate into US and Chinese national and municipal programs.

Potential Annual Savings by 2025

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy savings in U.S. and Chinese existing commercial buildings (EJ)</td>
<td>2.36</td>
</tr>
<tr>
<td>CO₂ reductions in U.S. and Chinese existing commercial buildings (MtCO₂)</td>
<td>2.14</td>
</tr>
</tbody>
</table>
Collaboration Focus Areas:

- Develop and pilot new, innovative, financial products.
  - green bonds
  - asset-backed securities
- Green finance internet portal.
- Information on leading-edge technologies
- Training program for bankers on EE financing.
- Data transparency policies and M&V Tool.
- Best-practices and case studies.
- ABC study tour with Citi to US.
Financing: Progress and Accomplishments
US-China Bilateral Stakeholder Workshop

Key Barriers:
- Lack of structures to support assessment of EE project creditworthiness efficiently and at scale (US and China).
- Lack of technical capacity for EE, data transparency, and M&V standards and tools (China).

Exploratory Solutions:
- Data transparency and benchmarking policies.
- Building energy audit and M&V tool.
- Standardized energy performance contracts.
- Credit information products.

Communications:

Next Steps:
- (FY16) Finalize ECEEE paper; summary report to DOE on barriers and solutions for building EE financing; (FY17) develop program model; (FY18) conduct pilot activities with Citi, IFC, and ABC; (FY19) city EE retrofit/financing pilot project; (FY20) training and tools for scale-up.
# US Industry and Global Benefits

### US Industry Benefits:

- **Access to world class scientists in US and China, resulting in accelerated technology development.**
- **First-hand knowledge of China’s energy policies, plans, and programs, allowing US companies to target their exports.**
- **Intellectual property (IP) framework that establishes clear and enforceable guidelines for US companies in China.**
- **Opportunity to build relationships and influence technology standards in China, increasing the competitiveness of US companies overseas.**
- **Expanded market for building EE in the US and China valued at US$ 60 billion per year by 2025.**

### Global Benefits:

- **Innovative policies and tools to expand the market for building EE technologies globally, generating both environmental and economic benefits.**
- **Demonstration of outcome-based code implementation in the US and China to advance global uptake (only a few global examples to-date).**
- **Enhanced data transparency policies and an open-source audit tool to facilitate cost-effective retrofit identification, M&V, and policy development and EM&V globally.**
- **Innovative financial products that leverage capital markets to meet global building EE investment requirements of $3.8 trillion by 2035 (Rugova 2016).**
- **A system dynamics model framework that can be applied to any country, or any region in a country.**
REFERENCE SLIDES
References


## Savings Assumptions

<table>
<thead>
<tr>
<th>Technology/Tool/Policy</th>
<th>US</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential and/or non-residential:</td>
<td>Commercial (New and Retrofit) Residential (New)</td>
<td>Commercial (New and Retrofit) Residential (New)</td>
</tr>
<tr>
<td>Maximum potential annual energy savings for each end use by 2025, in quads/yr</td>
<td>Comm Heating: 0.2; Comm Cooling: 0.3; Comm DHW: &lt;0.1; Commit Ventilation: 0.2; Comm Cooking: &lt;0.1; Comm Lighting: 0.3; Comm Refrigeration: 0.1; Comm Equip: 0.2; Comm Other: 0.7; Res Heating*: 0.1; Res Cooling: 0.1; Res DHW*: &lt;0.1; Res Refrigeration: &lt;0.1; Res Cooking: &lt;0.1; Res Clothes Dryers: &lt;0.1; Res Freezers: &lt;0.1; Res Lighting: 0.1; Res Clothes Washers: &lt;0.1; Res Dishwashers: &lt;0.1; Res TV: &lt;0.1; Res Computers: &lt;0.1; Res Furnace Fans: &lt;0.1; Res Other: 0.1 TOTAL: 2.5 Quads/yr (sum of sub-items not equal to total due to rounding) *Includes some fuel switching to electric heat pumps but assumes a fixed electric grid emissions factor.</td>
<td>Comm Heating*: 0.4 Quads/yr; Comm Cooling: 0.5; Comm Lighting: 0.8; Comm DHW*: 0.2; Comm Equip/Plugs: 0.5; Res Heating*: 0.4; Res Cooling: 0.1; Res Lighting: 0.1; Res DHW*: &lt;0.1; Res Cooking: &lt;0.1; Res Appliances/Plugs: 0.1 TOTAL: 3.2 Quads/yr (sum of sub-items not equal to total due to rounding) *Includes some fuel switching to electric heat pumps but assumes a fixed electric grid emissions factor.</td>
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<tr>
<td>Maximum Annual CO₂ Reduction by 2025 (Million tons CO₂)</td>
<td>240 MtCO₂e/yr</td>
<td>300 MtCO₂e/yr</td>
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<tr>
<td>Percent realistic 2025 market penetration assumption(s) (based on 2010)</td>
<td>Savings above represent a realistic adoption rate. The Reinventing Fire analysis did not analyze maximum technical potential. Rather, results represent realistic incremental adoption of efficiency, above a reference scenario with EIA projected business-as-usual efficiency improvements.</td>
<td>Savings above represent a realistic adoption rate. The Reinventing Fire research collaboration between LBNL, ERI and RMI did not analyze maximum technical potential. Rather, results represent realistic incremental adoption of efficiency, above a reference scenario with only modest business-as-usual efficiency improvements. Adoption rates based on official Chinese government expectations.</td>
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<tr>
<td>Annual global market size for proposed technologies ($ USD)</td>
<td>~$60 billion incremental capital expenditures in 2025 in combined U.S. and China market (2010$, non-discounted).</td>
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</tbody>
</table>
**Variance**: None.

**Cost to Date:**
- (b) Funds received: $340,000
- (c) Cost to-date: $241,598
- **U.S. Industry Cost-share**
- (a) Contributions to-date: $750,000
- (b) FY16 total: $1,000,000

### Additional Funding

<table>
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<tr>
<th>US Industry Partner</th>
<th>FY17 Industry In-Kind Contribution ($K)</th>
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<tr>
<td>RMI</td>
<td>75</td>
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<tr>
<td>UTC</td>
<td>100</td>
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<tr>
<td>Lutron</td>
<td>100</td>
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<td>Citi</td>
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<td>JCI</td>
<td>1,073</td>
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<td>NRDC</td>
<td>25</td>
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<td><strong>Total</strong></td>
<td><strong>1,473</strong></td>
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</table>

### Budget History

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<tr>
<th>FY 2016 (past)</th>
<th>FY 2017 (current)</th>
<th>FY 2018 – FY2020 (planned)</th>
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<tbody>
<tr>
<td>DOE 340K</td>
<td>DOE 400K</td>
<td>DOE 1.2M</td>
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<tr>
<td>Cost-share 1M</td>
<td>Cost-share 1.473M</td>
<td>Cost-share 4.419M</td>
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</table>
### Outcome-Based Codes and Impact Model: Project Plan and Schedule

**Outcome-Based Codes and Impact Model:**

**Project Plan and Schedule**

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<thead>
<tr>
<th>Activity</th>
<th>Task</th>
<th>Q1</th>
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<td><strong>1. Outcome-Based Codes</strong></td>
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<td>1.1</td>
<td>Assess US, China, and International Outcome-Based Codes; Assess Sensitivity of Operating Conditions on Energy Use Intensity (EUI)</td>
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<td>1.2</td>
<td>Develop Methodology for Establishing Outcome-based Codes in US Cities (e.g., NYC) Aligned with Current Code Efficiency Requirements</td>
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<td>1.3</td>
<td>Apply/Pilot Methodology for Establishing Outcome-based Codes Aligned with Current (D1) and Future (D2) Prescriptive Codes</td>
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<td>1.4</td>
<td>DOE and MOHURD Education/Training Materials</td>
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<td>1.5</td>
<td>Recommendations for Expanding DOE Asset Score</td>
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<td>1.6</td>
<td>Parameters for Model Energy Code in US / Chinese AEDG</td>
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<td><strong>2. Impact Model</strong></td>
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<td>2.1</td>
<td>Adapt Impact Model for CERC-BEE 2.0</td>
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<td>2.2</td>
<td>Modify Impact Model to Project Demographic and Economic Factors</td>
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<td>2.3</td>
<td>Perform Policy Scenario Analysis and Share Results</td>
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<td>2.4</td>
<td>Finalize Open-Source Impact Model and Deliver to DOE</td>
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<td>2.5</td>
<td>Calculate Overall Impact of CERC-BEE Program</td>
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**CERC-BEE Fiscal Year (FY):** April 1 to March 31

**Project Start:** April 1, 2016

**Project End:** March 31, 2021

“D”: a deliverable during that quarter. “G”: a Go/No-Go decision

◆ Milestone met on time. ◆ Missed milestone.
## Project Plan and Schedule

**CERC-BEE Fiscal Year (FY):** April 1 to March 31  
**Project Start:** April 1, 2016  
**Project End:** March 31, 2021  

<table>
<thead>
<tr>
<th>Activity</th>
<th>Task</th>
<th>Q1</th>
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<tbody>
<tr>
<td>3. Data</td>
<td>3.1 Solidify Partnerships</td>
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<td>3.2 Identify and Recommend Disclosure Fields for Retrofit Identification (D1), M&amp;V (D2), and EM&amp;V (D3).</td>
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<td>3.3 Pilot in US and China (D1), Quantify Impact, and Share Results (D2)</td>
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<td>4. Audit Tool</td>
<td>4.1 Develop Database</td>
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<td>4.2 Develop Source Code and Publish to GitHub</td>
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<td>4.3 Coordinate with US-China EPC Working Group</td>
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<td>4.4 Develop Web-Based Audit Tool</td>
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<td>4.5 Continue to Improve Tool Usability and Fix Bugs</td>
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<td>4.6 Evaluate Opportunity to link tool to ENERGY STAR and Asset Score</td>
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<td>4.7 Identify Common Technical Energy-Saving Measures</td>
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<td>4.8 Pilot Tool, Quantify Impact, Share Results</td>
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<td>4.9 Promote Uptake</td>
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<td>5. Finance</td>
<td>5.1 US-China Stakeholder Engagement Workshop</td>
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<td>5.2 Evaluate Opportunities to Develop and Pilot New Solutions to Facilitate Investment in BEE</td>
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<td>5.3 Conduct Pilot Activities with Citi-IFC-ABC</td>
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<td>5.4 Conduct City-level Retrofit/Financing Pilot Project</td>
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<td>5.5 Develop Tools and Resources for Scale-up</td>
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“D”: a deliverable during that quarter.  “G”: a Go/No-Go decision

- ◆ Milestone met on time.  ◆ Missed milestone.