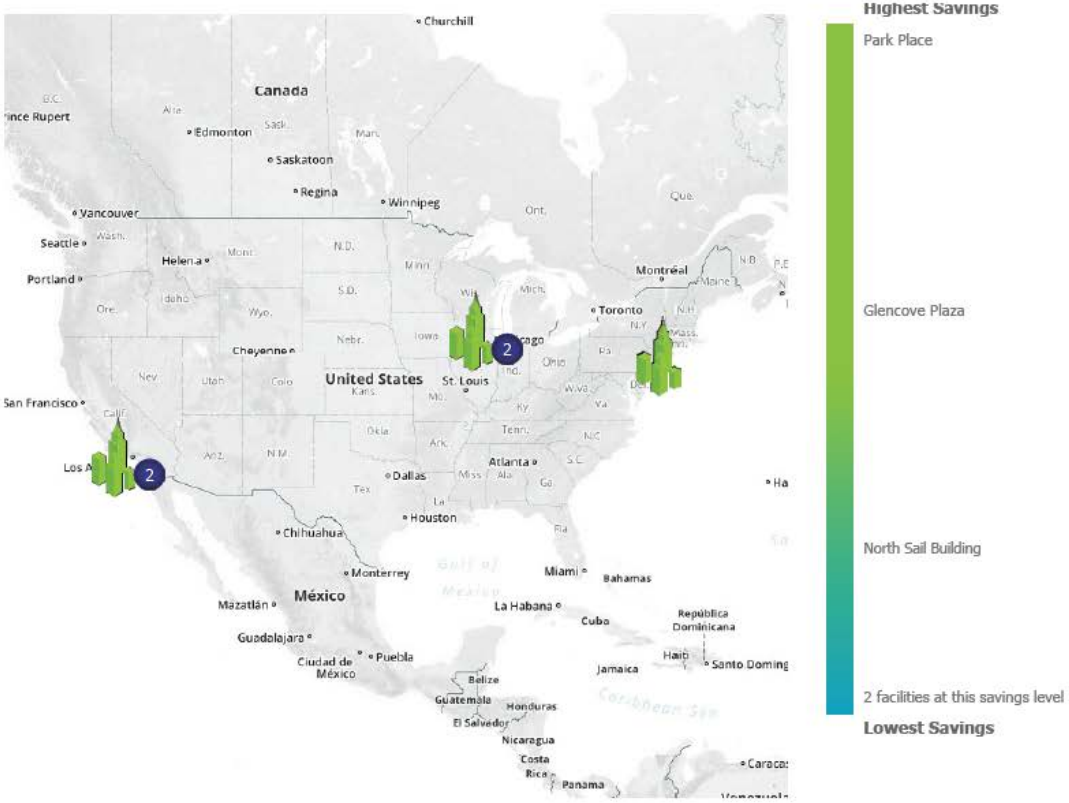
U.S.-China Clean Energy Research Center Building Energy Efficiency (CERC-BEE)

Markets and Policy Initiative

2017 Building Technologies Office Peer Review

Executive Summary of Opportunity



Total Potential Savings

$603,000

Top Individual Potential Savings

Park Place Savings	290,000
Glencove Plaza Savings	180,000
North Sail Building Savings	90,000
Delway Building Savings	33,000
Washington Plaza Savings	10,000

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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:	China:
• 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 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 usage[1] 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).

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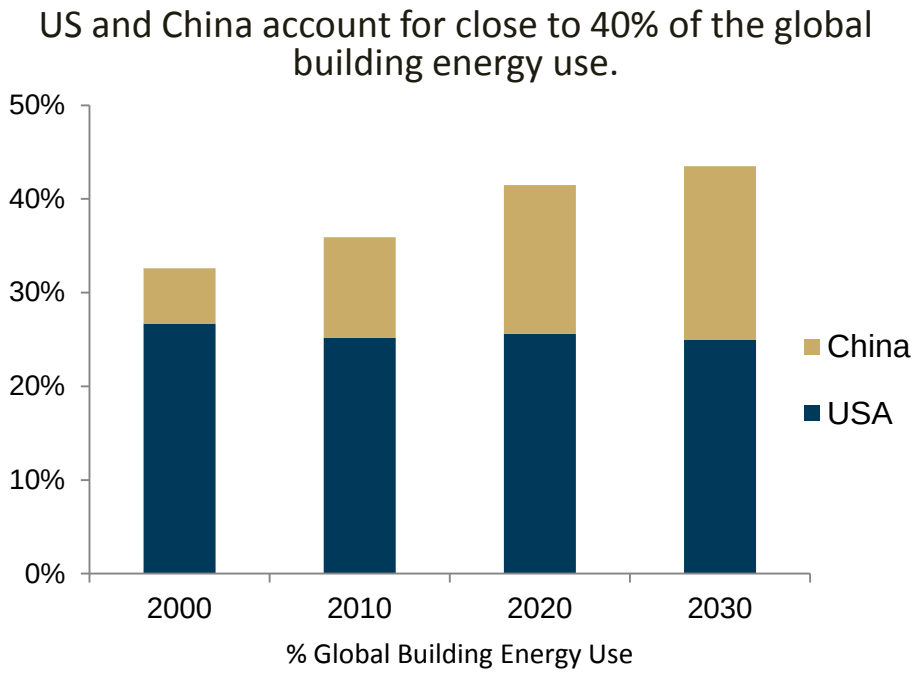
Purpose and Objectives

Problem Statement:



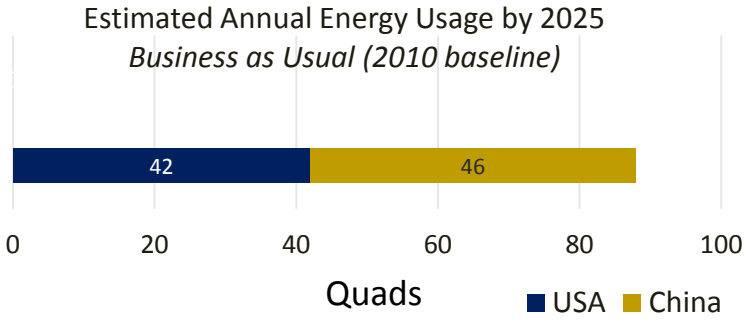
Target Market:

- 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**.

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).

Market Size:



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 CO_2); 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

Long-Term Outcome and Impact

2025 Annual Savings	US	China	Total
Energy savings (quads)	2.5	3.2	5.7
Percent savings (2010 base year)	6%	7%	13%
CO_2 reductions ($MtCO_2$)	240	300	540

Outcome-based Codes: Team, Approach, Outputs

Partners, Subcontractors, and Collaborators

Outputs

- ✓ **New standards**: model code for US and Chinese Advanced Energy Design Guide (AEDG).
- ✓ **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.

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 (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

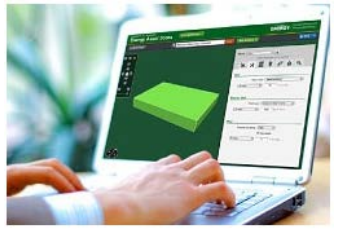
- Training curriculum, including case studies.
- Delivery to DOE, MOHURD, and US and Chinese cities (e.g., Washington, DC).

FY20: New Standards

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

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)

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5

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.

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 CO_2 emissions.

FY18. Data disclosure points for better policy EM&V.

- Perform policy scenario analysis using Impact Model and share results with DOE and MOHURD.

FY19. City Pilot Projects.

- 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.

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

Open-Source Audit Tool: Approach, Team, Outputs

Partners, Subcontractors, and Collaborators

BERKELEY LAB · ICF INTERNATIONAL · Johnson Controls · CABEE · STE · CRC

Distinctive Characteristics:

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

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

FY16. Database and US-China Joint Intellectual Property Management Plan (IPMP).

FY17. Audit tool source code published to GitHub

- Coordination with Energy Performance Contract (EPC) Working Group.

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

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

SEED PLATFORM · U.S. DEPARTMENT OF ENERGY · Better Buildings · U.S. DEPARTMENT OF ENERGY · ENERGY STAR · DOE Commercial Building Energy Asset Score · Pacific Northwest NATIONAL LABORATORY · DOE BUILDINGS PERFORMANCE DATABASE

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

Financing: Approach, Team, and Outputs

Partners, Subcontractors, and Collaborators

BERKELEY LAB · citi · IFC International Finance Corporation WORLD BANK GROUP · 中国农业银行 AGRICULTURAL BANK OF CHINA · 保尔森基金会 PAULSON INSTITUTE · 浦发银行 SPD BANK · STC

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.

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

FY16. Host US-China Bilateral Workshop "Barriers and Solutions to Building Energy Efficiency Retrofits."

FY17. Develop program model:

- Sunshot-Catalyst
- Standardized EPC
- New credit information products
- G20 collaboration

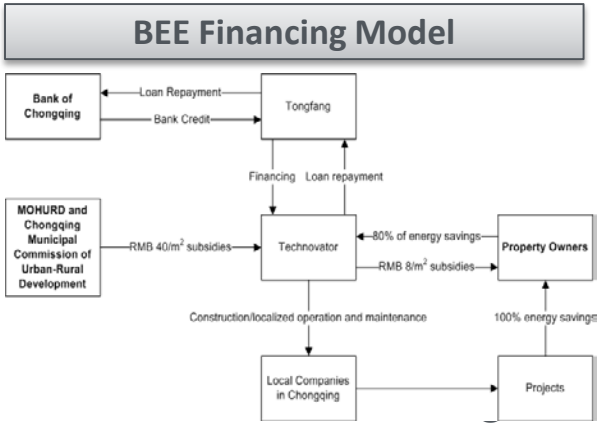
FY18. Citi-IFC-ABC Pilot

- Specialized financial EE products
- "Green Finance" internet portal
- Case studies
- Information on leading-edge building EE technologies
- Training for bankers

FY19. City Retrofit /Financing Pilot Project

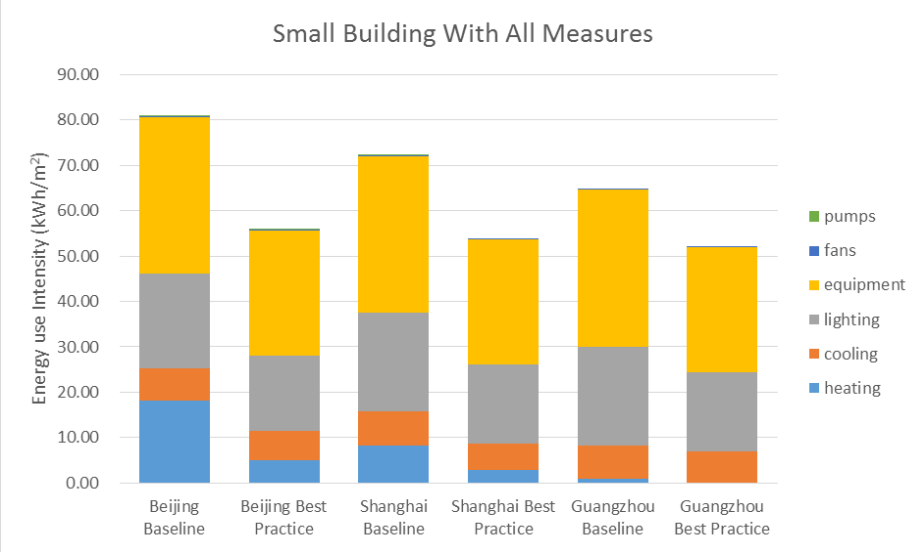
- Washington DC (?)
- California (?)
- Wuhan, China (?)

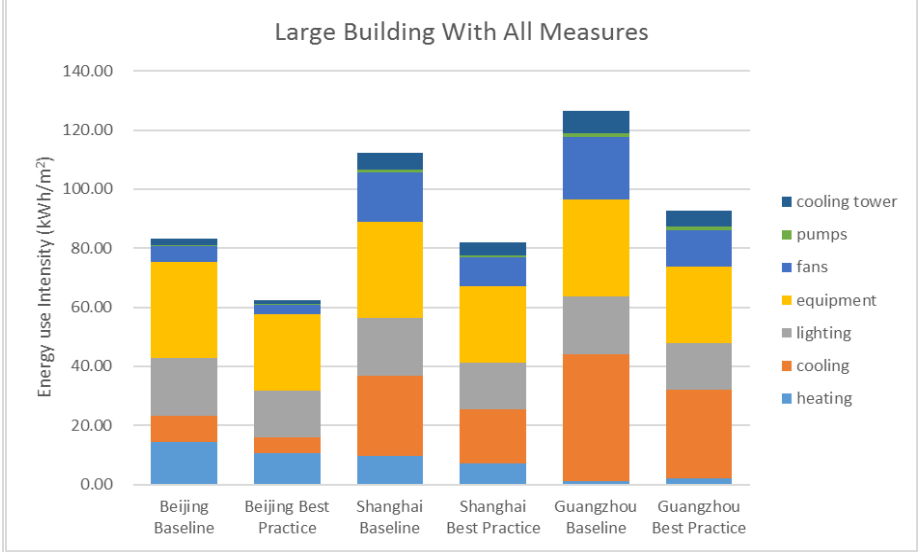
FY20. Tools and resources for scale-up



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

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).

Performance (kwh/m²)	Prescriptive Baseline	Best practice	Outcome based required target		Outcome based Recommended target	
			Government office	Commercial office	Government office	Commercial office
Small office (Cat A)	72.19	53.82	70	85	50	70
Large office (Cat B)	112.22	81.82	90	110	65	80

- 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.

9

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Operating Conditions Can Have Impacts on Outcome-Based Performance

		Beijing		Shanghai		Guangzhou	
		Savings, kWh/m2	Savings ratio	Savings, kWh/m2	Savings ratio	Savings, kWh/m2	Savings ratio
Small Office Building	cooling setp	0.61	0.75%	0.81	1.12%	0.11	0.17%
	heating setp	2.8	3.47%	2.98	4.13%	0.59	0.92%
	lighting use	3.86	4.78%	4.12	**5.70%**	4.36	**6.74%**
	equip use	6.27	**7.76%**	6.35	**8.80%**	6.9	**10.67%**
	natural ventilation	1.01	1.25%	7.68	**10.64%**	1.18	1.82%
	shading	0.2	0.25%	0.11	0.15%	0.16	0.24%
Large Office Building	**cooling setp**	1.38	1.66%	11.86	**10.57%**	17.81	**14.09%**
	heating setp	3.17	3.81%	3.58	3.19%	3.94	3.12%
	lighting use	4.43	**5.33%**	7.23	6.44%	9.16	**7.25%**
	equip use	7.17	**8.63%**	10.85	**9.67%**	13.01	**10.29%**
	Natural Ventilation	10.71	**11.62%**	14.19	**12.10%**	14.87	10%
	shading	0.77	0.93%	3.27	2.91%	4.63	3.66%
	economizer	0.34	0.41%	2.36	2.10%	4.06	3.22%
	SA reset	1.15	1.38%	2.34	2.08%	3.96	3.13%

- **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.

10

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

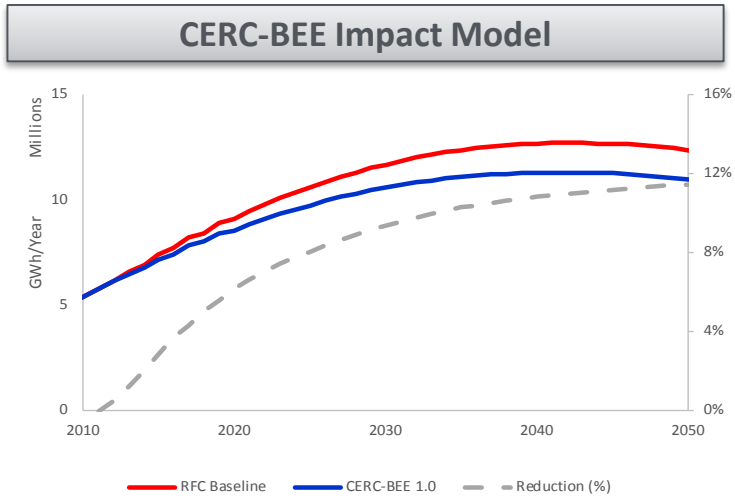
- Product and building turnover models, including a realistic model for product adoption.
- System dynamics permits dealing with complexity of behavior as well as complexity of detail.
- Models counter-intuitive effects like policy resistance.

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 CO_2 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.

11

Research Findings and Policy Recommendations

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.

	Building Performance Database (BPD)	C3 Commercial	Agilis Energy	FirstFuel	Chicago Loop Energy Retrofit Tool (Chicago area only)	HELiOS	Retroficiency/Ecova	Consortium for Building Energy innovation (CBEI)	Commercial Building Energy Saver (CBES)	Customized Calculation Tool (CCT)	Johnson Controls Inc. (JCI) LEAN Energy Analysis
Tool Inputs											
Accessibility for the public (Yes/No)	Yes	No	No	No	No	No	No	[a]	Yes	Yes	No
Utility Bills	X [b]	X	X	X	X	X	X	X	X	X	X
Time Series Interval Energy Data		X	X	X		[a]	X		X		
Climate/Weather Data [c]	X	X	X	X	X	X	X	X	X	[a]	X
Simple Building Characteristics [d]	X	X	X	X	X	X	X	X	X	X	X
Detailed Building Characteristics [e]					X	X	X	X	X	X	
Tool Outputs											
Energy and Cost Savings Estimates	X	X	X	X	X	X	X	X	X	X	X
Recommended ECMs	X	X	X	X	X	X	X	X	X	X	X
Benchmark Again Peers	X	X	[a]	X					X		X

Lee, Hong, and Piette 2015

[a] Unknown; [b] Yearly source and site EUI; [c] 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); [d] Includes building type, vintage, floor area, occupancy density; [e] Goes beyond that listed in the simple category

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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 m^2. For 20,000 m^2 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.

Communications: 2017 ECEEE Summer Study Paper: *Lessons from the United States and China for Increasing Transparency and Harmonizing Monitoring and Verification Practices in the Buildings Sector.*

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.

Draft US-China Intellectual Property Management Plan (IPMP)

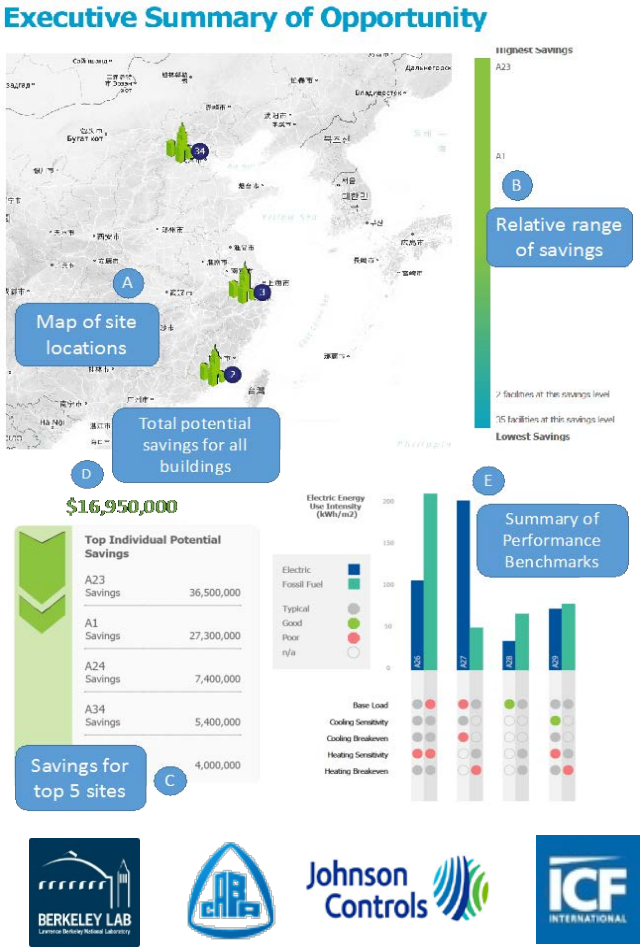
- CERC 1.0 Benchmarking Tool being incorporated into Chinese national ***Code for Operation and Management of Central Air Conditioning System GB50365***.

- **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:**
  - 2016 ACEEE Summer Study Paper: *Opportunities for Realizing Drastic Reductions in Building Sector CO_2 Emissions through U.S.-China Collaboration.*
  - 2017 ECEEE Summer Study Paper: *Lessons from the United States and China for Increasing Transparency and Harmonizing Monitoring and Verification Practices in the Buildings Sector.*

- **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.



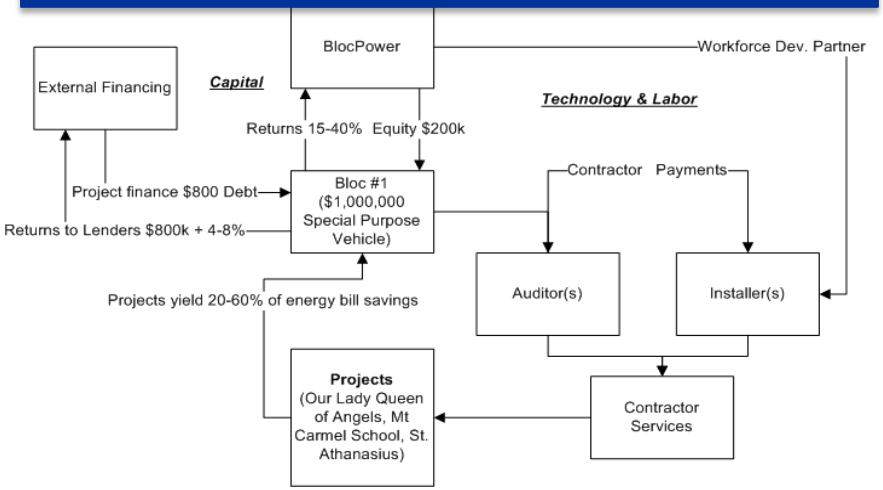
Potential Annual Savings by 2025	Total
Energy savings in U.S. and Chinese existing commercial buildings (EJ)	2.36
CO_2 reductions in U.S. and Chinese existing commercial buildings ($MtCO_2$)	2.14

14

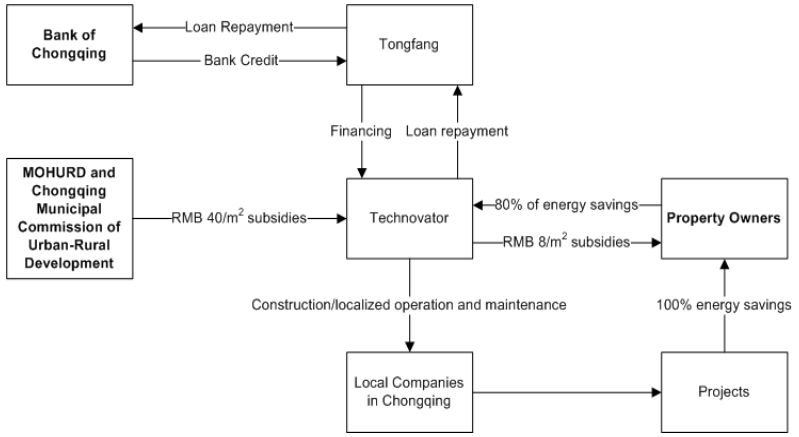
LBNL – IFC – Citi – ABC Collaboration Launch

- 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.

US: BlocPower Crowdfunding Model



Chongqing Building EE Retrofit Financing Model



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:

- 2017 ECEEE Summer Study Paper: *Lessons from Europe, North America, and Asia: Financing Models that are Facilitating Building Energy Efficiency at Scale.*

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.

Mao Qin, Changning Low Carbon District

Li Deying, China Association of BEE

Antonio Ruiz, DOE

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

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Savings Assumptions

Technology/Tool/Policy	US	China
End use(s) impacted:	Commercial Heating, Cooling, DHW, Ventilation, Cooking, Lighting, Refrigeration, Equip, Other. Residential Heating, Cooling, DHW, Refrigeration, Cooking, Clothes Dryers, Freezers, Lighting, Clothes Washers, Dishwashers, TV, Computers, Furnace Fans, Other	Commercial Heating, Cooling, Lighting, DHW, Equipment & Plugs Residential Heating, Cooling, Lighting, DHW, Cooking, Appliances & Plugs
Residential and/or non-residential:	Commercial (New and Retrofit) Residential (New)	Commercial (New and Retrofit) Residential (New)
Maximum potential annual energy savings for each end use by 2025, in quads/yr	Comm Heating: 0.2; Comm Cooling:0.3; Comm DHW: <0.1; Comm Ventilation: 0.2; Comm Cooking: <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*: <0.1; Res Refrigeration: <0.1; Res Cooking: <0.1; Res Clothes Dryers: <0.1; Res Freezers: <0.1; Res Lighting: 0.1; Res Clothes Washers: <0.1; Res Dishwashers: <0.1; Res TV: <0.1; Res Computers: <0.1; Res Furnace Fans: <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.	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*: <0.1; Res Cooking: <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.
Percent maximum potential annual energy savings for each end use by 2025, (2010 base year).	Comm Heating: 10%; Comm Cooling: 14%; Comm DHW: 5%; Comm Ventilation: 12%; Comm Cooking: 9%; Comm Lighting: 8%; Comm Refrigeration: 10%; Comm Equip: 11%; Comm Other: 9%; Res Heating*: 1%; Res Cooling: 3%; Res DHW*: 1%; Res Refrigeration: 2%; Res Cooking: 1%; Res Clothes Dryers: 1%; Res Freezers: 2%; Res Lighting: 4%; Res Clothes Washers: 3%; Res Dishwashers: 1%; Res TV: 1%; Res Computers: 3%; Res Furnace Fans: 1%; Res Other: 2% **OVERALL: 6%** *Includes some fuel switching to electric heat pumps but assumes a fixed electric grid emissions factor.	Comm Heating*: 9%; Comm Cooling: 13%; Comm Lighting: 14%; Comm DHW*: 15%; Comm Equip/Plugs: 16%; Res Heating*: 3%; Res Cooling: 4%; Res Lighting: 3%; Res DHW*: 3%; Res Cooking: 1%; Res Appliances/Plugs: 3% **OVERALL: 7%** *Includes some fuel switching to electric heat pumps but assumes a fixed electric grid emissions factor.
Maximum Annual CO_2 Reduction by 2025 (Million tons CO_2)	240 $MtCO_2e/yr$	300 $MtCO_2e/yr$
Percent realistic 2025 market penetration assumption(s) (based on 2010)	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.	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.
Annual global market size for proposed technologies ($ USD)	~$60 billion incremental capital expenditures in 2025 in combined U.S. and China market (2010$, non-discounted).	

Project Budget

Variances: 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	
US Industry Partner	FY17 Industry In-Kind Contribution ($K)
RMI	75
UTC	100
Lutron	100
Citi	100
JCI	1,073
NRDC	25
Total	1,473

Budget History

FY 2016 (past)		FY 2017 (current)		FY 2018 – FY2020 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
340K	1M	400K	1.473M	1.2M	4.419M

Outcome-Based Codes and Impact Model:
Project Plan and Schedule

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

Activity	Task	BTO FY16	BTO FY17			BTO FY18				BTO FY19				BTO FY20				BTO FY21
		CERC-BEE FY16				CERC-BEE FY17				CERC-BEE FY18				CERC-BEE FY19				CERC-BEE FY20			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Outcome-Based Codes	1.1 Assess US, China, and International Outcome-Based Codes; Assess Sensitivity of Operating Conditions on Energy Use Intensity (EUI)				D																
	1.2 Develop Methodology for Establishing Outcome-based Codes in US Cities (e.g., NYC) Aligned with Current Code Efficiency Requirements								D												
	1.3. Apply/Pilot Methodology for Establishing Outcome-based Codes Aligned with Current (D1) and Future (D2) Prescriptive Codes												D1			D2					
	1.4 DOE and MOHURD Education/Training Materials																D				
	1.5 Recommendations for Expanding DOE Asset Score																	D			
	1.6 Parameters for Model Energy Code in US / Chinese AEDG																				D
2. Impact Model	2.1 Adapt Impact Model for CERC-BEE 2.0				D																
	2.2 Modify Impact Model to Project Demographic and Economic Factors									D											
	2.3 Perform Policy Scenario Analysis and Share Results										D										
	2.4 Finalize Open-Source Impact Model and Deliver to DOE													D							
	2.5 Calculate Overall Impact of CERC-BEE Program																				D

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

◆ Milestone met on time. ◆ Missed milestone.

Completed work

Current/Future work

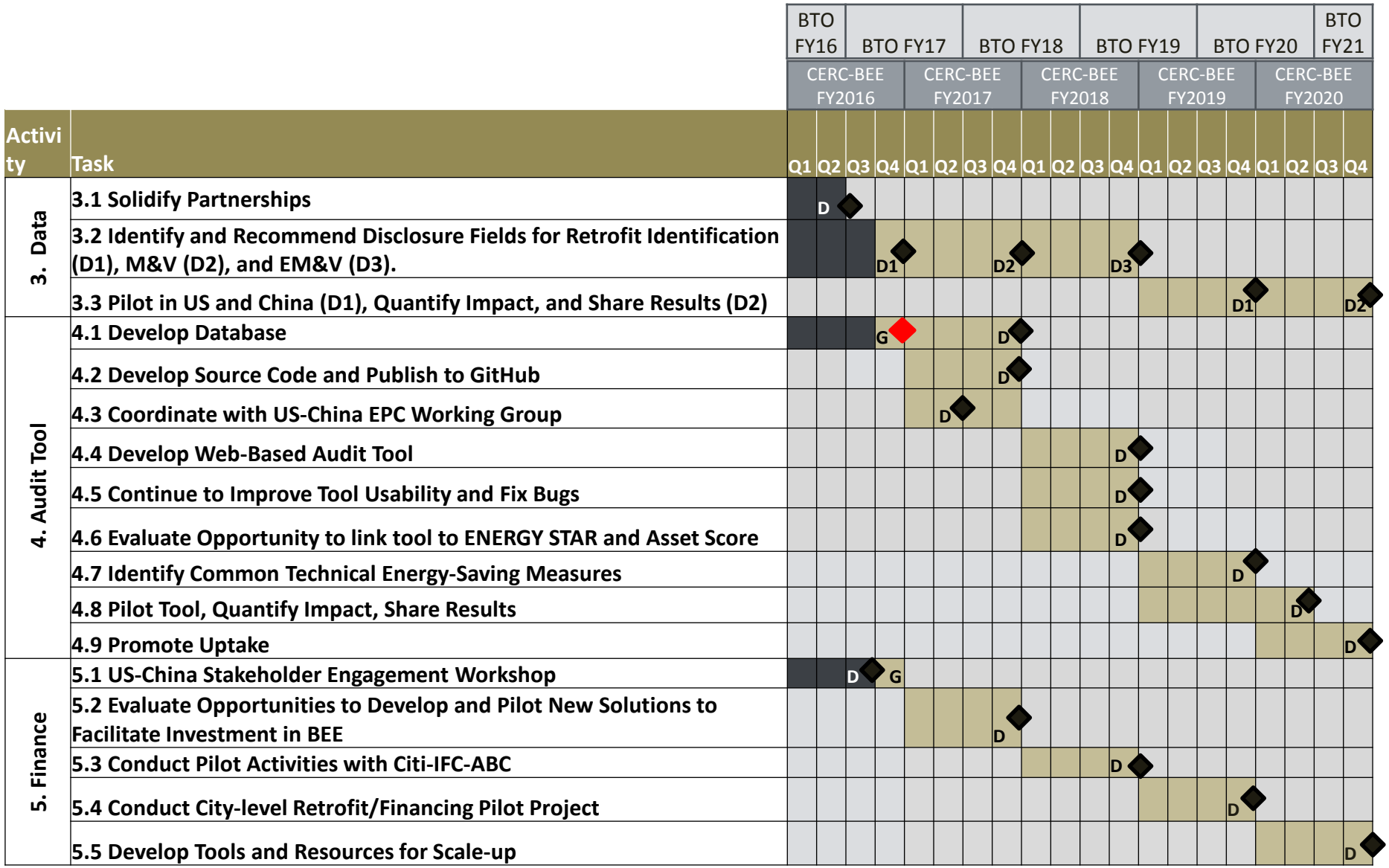
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

22

Data Transparency/Audit Tool/Finance:

Project Plan and Schedule

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.