

CCC/IOU Energy Efficiency Partnership  
MBCx Workshop  
California Community College's  
Chancellor's Office  
September 18, 2009



# Monitoring Based Commissioning (MBCx) for California Community Colleges

Guidelines, Requirements, and Processes



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CCC/IOU MBCx Workshop

# CCC/IOU Energy Efficiency Partnership

## *Program Overview*

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## California Community Colleges

The largest system of Public Higher Education in the world

- **CCC's serve 2.7 million students annually**
  - Over 70% of the state's public college students
- **One-Quarter of all community college students in U.S. are enrolled in California's Community Colleges**

# California Community Colleges

## *Challenges and Opportunities*

### **System-wide Detail**

- **Seventy-two districts encompassing 110 campuses, 69 approved off-campus centers and 22 separately reported district offices**
- **Includes 21,600 acres of land, 4,885 buildings, and 64.4 million gross square feet of space**
- **Innumerable off-campus outreach centers at various facilities**

# California Community Colleges

## *Challenges and Opportunities*

### System-wide Facilities Needs

- \$35+ Billion over next 10 years
- Five year needs in new & existing facilities
  - Enrollment Growth = 15m new ASF
  - Modernization = 28m ASF of existing building
    - 74% over 25 years old
    - 60% over 40 years old

# California Community Colleges

## *Challenges and Opportunities*

### Available Resources

- 64 of 72 districts = \$22.8b in local bonds
  - Since Prop 39 in November 2000
- State CCC funds for capital outlay
  - 2006 State Education Bond = \$1.5 billion
  - 2010 State Education Bond = \$4.1 billion (SB 271, Ducheny)

## CCC Board of Governors

### Energy and Sustainability Policy

- Adopted in January 2008 as a template for use by all 72 CCC Districts
- Beginning in 2010-11, incentive funding available for state funded projects:
  - 2% of construction costs for New Buildings that exceed Title 24 by 15%
  - 3% of construction costs for Modernization Projects that exceed Title 24 by 10%

## CCC/IOU Energy Efficiency Partnership

- This collaborative Partnership is designed to:
  - Identify energy savings opportunities
  - Provide funding and support for energy efficiency design and projects
  - Provide a framework to implement a comprehensive sustainability policy
- Partners include:
  - All four IOUs: SCE, SDG&E, SCG, PG&E
  - CCC Chancellor's Office and 72 Districts
  - Newcomb | Anderson | McCormick
    - Program administration and management

# Program Elements

- Energy Efficient Retrofit projects
- Monitoring-Based Commissioning (MBCx)
- Emerging Technologies
- New Construction for Partnerships / Savings by Design - whole building and systems approaches
- Demand Response
- Climate Change programs
- Renewables
- Training and Education activities

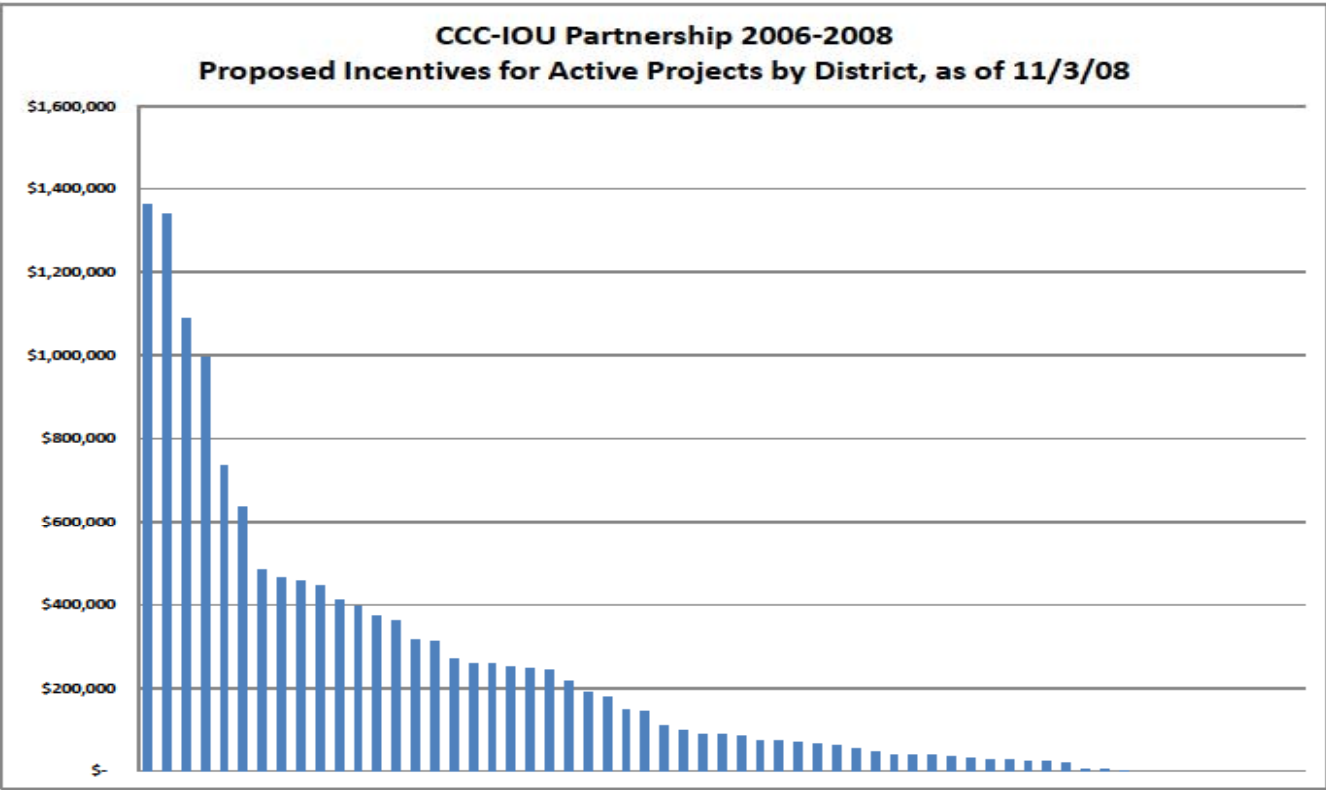
*No kWh (or therm) left behind!*

## 2006-2008 Accomplishments

- Energy Savings accomplished to date
  - 8.7 MW
  - 33.9 million Kwh
  - Over 1 million Therms
  - 25,000 tons CO2 reduction annually -equivalent to nearly 3,400 cars/year off the road!
- Incentives to Districts
  - \$20.7 program incentive budget
  - \$8.3 million paid for completed projects
  - ***Over \$12 million in Incentives left on the table - this money did not roll over into 2009!***

# CCC/IOU MBCx Workshop

## 2006-2008 *Who got the money?*



# CCC/IOU Partnership Estimated Life Cycle Benefits \*

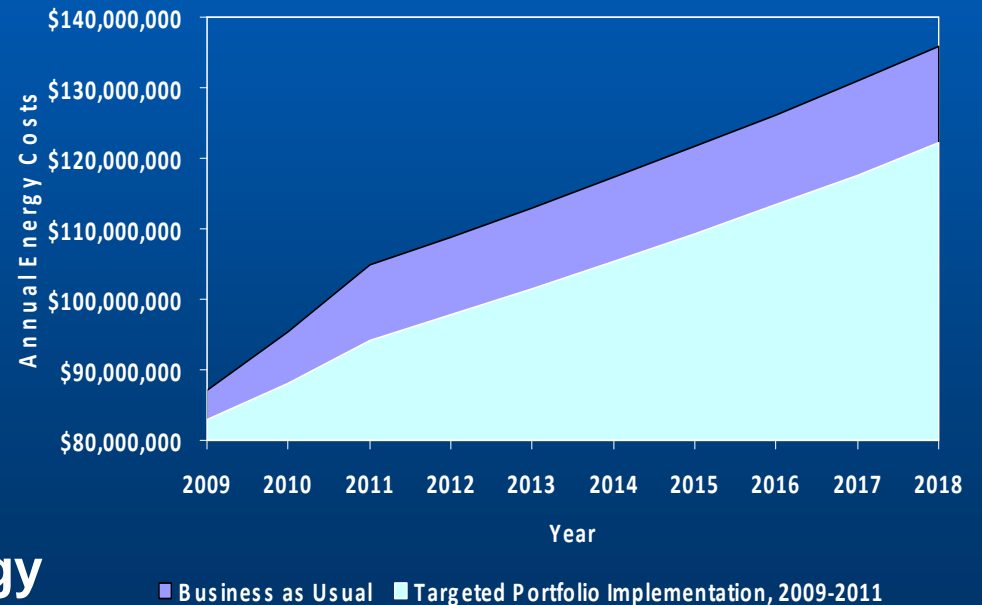
## 10-Year Cumulative Energy Impacts

Electricity Savings =  
725,562,048 kWh

Natural Gas Savings =  
23,080,884 therms

For every \$1 spent for sustainable facilities yields AT LEAST \$2 energy savings

10 Year Effects of 3-Year Program Implementation  
Statewide CCC Campus Energy Costs (IOU Served Campuses Only)



\* Calculated for 2009-2011 Program Cycle

## Plans for 2009, 2010-2012 Program Cycles

### *CPUC Proposed Decision Released August 25th*

- Proposes a 2009 program as “stand alone” and a new 2010-2012 Program Cycle
- “Statewide Partnerships”, including CCC/IOU, UC/CSU, CDCR and DGS approved as submitted by IOUs
- Directs reductions in Administrative, Marketing, Education and Outreach costs
- Comments due 9/14/09 with Final Decision expected by 9/24/09

PD can be viewed at:

<http://docs.cpuc.ca.gov/efile/PD/106166.pdf>

# CCC/IOU MBCx Workshop

## Program Incentives for 2009 and 2010-2012

Proposed 2009-2011 CCC/IOU Program	
Measure	Incentive Rate
Packaged HVAC, HVAC Controls, Motors, Drives	\$0.24/kWh
Lighting, Lighting Controls, Daylighting	
Central Plants, Chiller Retrofits, Whole Building, and other major Energy Efficiency Infrastructure Projects	
MBCx	
Plug and Process Loads	
IT Projects (PC Power Mgmt @ \$15/PC or \$0.24/kWh WITH IOU M&V)	
All Gas Measures	\$1.00/therm
50% project cost cap (lighting) 80% project cost cap (non-lighting) 100% Funding for PC Power Management (no bundling with other projects)	
No upfront payments	

## CCC/IOU MBCx Workshop

### New Construction for Partnerships (Savings by Design)

- Engage the IOUs early on in the process – submittal of FPP, Programming/Schematic stage of project development
- If projects are looking at LEED Certification or CHPS requirements, the NCP program works hand in hand with this process
- The requirements of NCP “Whole Building Program” mirror the modeling requirements for LEED Project submittals
- The Chancellor’s Office is developing a set of criteria which will recommend to every campus that they sign a letter of interest with the IOU to participate in the NCP program for all New Construction and Major Renovation Remodel projects
- IOUs are offering enhanced incentives to both the owners and design teams to engage them in the planning and implementation of energy efficiency in new projects

# CCC/IOU MBCx Workshop

## New Construction for Partnerships (Savings by Design)

### “Whole Building Approach” Incentives

Incentive	2009 Core Program	2009 Statewide Institutional Partnerships
<b>Owner Incentive \$/kWh</b>	<p>\$0.10 - 0.30/kWh</p> <p>Start at 10% over Title 24 (\$0.10/kWh) and will go up in an increment of \$0.001/kWh for every 0.1% over Title 24. The incentive will be capped at \$0.30/kWh for any project over 30% above Title 24.</p> <p>\$0.34 - \$1.00/therm</p>	<p>\$0.10 above Core. Escalate same rate as Core.</p> <p>\$1.00/therm with no escalation.</p>
<b>Owner Incentive kW “Kicker”</b>	\$100/kW	\$100/kW
<b>Design Team Incentive</b>	<p>1/3 of Owner Incentive and kW kicker. Includes rate escalation for percentage achieved over Title 24.</p> <p>Cap at \$50,000</p>	<p>1/3 of Owner Incentive and kW kicker. Includes rate escalation for percentage achieved over Title 24.</p> <p>Cap at \$50,000</p>

# Incentive Structure (SA: System Approach)

	<b>2008</b>	<b>2009 Savings By Design</b>	<b>New Construction Partnership</b>
<b>Daylighting</b>	\$0.04/kWh	\$0.05/kWh	\$0.15/kWh
<b>Interior Lighting</b>	\$0.05/kWh	\$0.05/kWh	\$0.15/kWh
<b>HVAC &amp; Ref.</b>	\$0.14/kWh	\$0.15/kWh	\$0.25/kWh
<b>Others</b>	\$0.08/kWh	\$0.09/kWh	\$0.19/kWh
<b>kW Kicker</b>	None	\$100/kW	\$100/kW

## *Leveraging New Construction Incentives*

- **BOG Sustainability Policy and Partnership NCP/SBD work together to provide additional energy saving incentives for campuses**
- **Ensure that Letter of Interest is submitted with District planning submittals to Chancellor's Office**
- **Contact your IOU representative or CCC Chancellor's office for details**

***Don't miss this exciting opportunity to leverage incentives!***

# Emerging Technologies in Energy Efficiency

## Emerging Technologies and Non-Traditional Retrofits Save Energy and Money

- **PIER Emerging Technologies – *Integrated Classroom Lighting Systems (ICLS), Bi-Level Stairwell Lighting, Wireless HVAC Controls***
- **Information Technology Projects – *PC Power Management, Server Virtualization, Desktop Virtualization***
- **Food Service Technologies – *Kitchen Exhaust Hood Demand Control Ventilation***



***The Partnership can help you implement these technologies!***

# How to Find the Money

- **Historical level of utility spending on utility programs = \$2 billion statewide over 3 years !!**
- **Energy \$Mart**
  - **Contact: Patrick Mullen, Department of General Services,(916) 375-4617**
- **CEC Loan Program**
  - **Contact: John Butler, California Energy Commission, (916) 654-3838**
- **Performance contracting – ESCO's**
  - **Customize approach to meet campus needs**
  - **Best source of information is from other CCC Districts**
- **Local and State Bonds**
- **Utility Financing Options**
- **Scheduled Maintenance Budget and Block Grant Funding**
- **Many projects pay for themselves in 3 -5 years through avoided costs**
- **Federal Stimulus (ARRA)**

# 2009 Fall Sustainability Training Series

### ***“Partnering for Sustainability”***

Four-course series focusing on sustainability in Higher Education facilities, and applicable operations and maintenance ideas to ‘green’ existing buildings which will help save energy, money & the environment. The fall 2009 series will be hosted and /or web and video cast to seven different Community College Campuses across California.

Date	IOU Sponsor	Course Name
10/16/2009	SDG&E	Introduction to Sustainability
10/30/2009	SCE	Transformers: Turning Existing Buildings Green
11/6/2009	PG&E	"Zero Net Energy" Lighting Systems
12/4/2009	SCG	The Water and Energy Connection

Enroll at <http://cccutilitypartnership.com/2009%20courses.html>  
See your local IOU representative for more info.

## *Be a Sustainability LEADER !*

### **Campuses Work in Partnership with the Utilities to**

- **Develop a local Sustainability / Energy Policy**
- **Brainstorm ideas for energy savings opportunities**
- **Energy Efficiency, Demand Response, Renewables, New Construction**
- **Perform an Energy Audit at their campus**
- **Attend a Partnership training and education session**
- **Get assistance with Project Application forms for CCC-IOU Partnership**
- **Engage other departments on campus that may have energy saving opportunities (such as IT and Foodservice)**

Questions – *how can we help you?*



For more information check Program Web Site at:

**[www.cccutilitypartnership.com](http://www.cccutilitypartnership.com)**

# Monitoring Based Commissioning (MBCx)

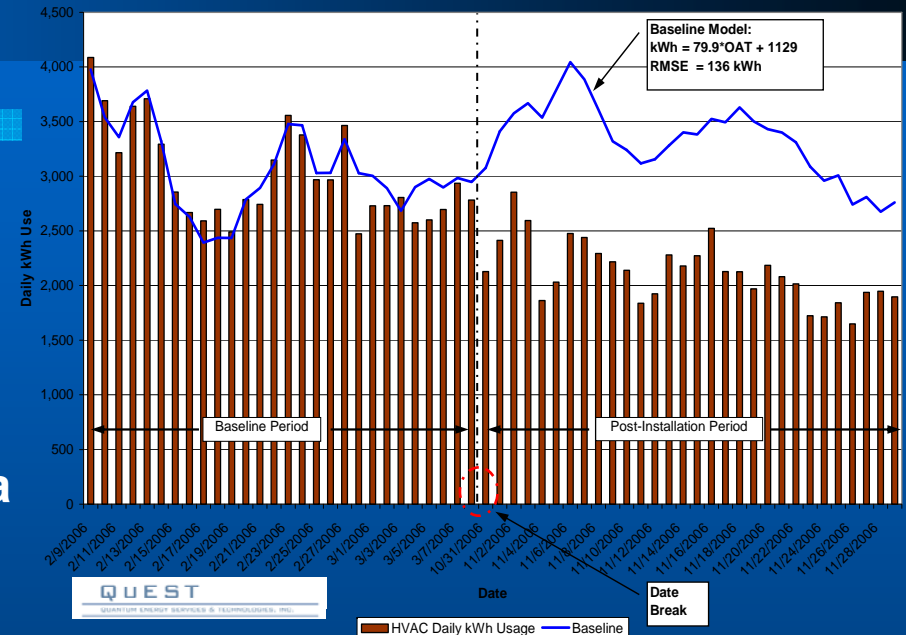


## Guidelines, Requirements, and Processes

Michael K.J. Anderson, P.E.  
Newcomb | Anderson | McCormick

## What is MBCx?

- **MBCx is a unique combination of building monitoring and commissioning.**
- **The monitoring supports the commissioning effort by providing a diagnostic tool, as well as by documenting energy savings in the near term and the persistence of those savings over the long term.**
- **The CCC/IOU program supports MBCx for individual or multiple buildings and Central Plants at college campuses.**
- **Significant experience in UC/CSU Systems – CCC expansion in 2009-2011**



# CCC/IOU MBCx Workshop

## Typical CCC Projects

Utility	Building Type	GSF	Est. Annual Electric Savings (kWh)	Est. Annual Gas Savings (therms)	Total Project Costs	Total Incentives	Net Cost to Campus	Est. Annual Energy Avoided Costs	Simple Payback (years)
SDG&E	Classrooms/Offices		265,956	8,027	\$133,751	\$93,133	\$40,618	\$ 38,336	1.1
PG&E	Classrooms/Offices	54,211	134,503	3,036	\$ 69,688	\$ 46,077	\$ 23,611	\$ 18,569	1.3
PG&E	Central Plant	20,087	157,807	11,154	\$ 80,193	\$ 61,652	\$ 18,541	\$ 27,860	0.7
PG&E	Central Plant		144,777	22,926	\$ 154,000	\$ 69,255	\$ 84,745	\$ 35,714	2.4
PG&E	Administrative	46,000	71,898	1,962	\$ 68,050	\$ 24,969	\$ 43,081	\$ 10,197	4.2
PG&E	Central Plant	2,200	66,788	7,283	\$ 93,800	\$ 28,655	\$ 65,145	\$ 13,841	4.7
PG&E	Cluster of Classroom/Office Buildings	43,668	27,063	3,537	\$ 45,500	\$ 12,197	\$ 33,303	\$ 6,077	5.5
PG&E	Classrooms/Offices	30,403	57,588	2,462	\$ 46,000	\$ 20,892	\$ 25,108	\$ 8,880	2.8
PG&E	Central Plant	2,800	152,068	18,639	\$ 89,700	\$ 67,300	\$ 22,400	\$ 33,159	0.7
<b>Total</b>			<b>1,078,448</b>	<b>79,026</b>	<b>\$ 780,682</b>	<b>\$ 424,130</b>	<b>\$ 356,552</b>	<b>\$ 192,635</b>	<b>1.9</b>

Note: Estimated annual energy avoided costs is calculated using \$0.12/kWh and \$0.80/therm

## Bundling Small Buildings

A CSU campus found it cost-effective to group several small buildings into one project. However, an application and reporting summary was completed individually for each building.

Building Type	Gross Square Footage	Est. Annual Electrical Savings (kWh)	Est. Annual Gas Savings (therms)	Total Project Costs	Total Incentives	Net Cost to Campus	Est. Annual Energy Avoided Costs	Simple Payback (years)
Theater/Workshop Space	7,898	8,646	199	\$ 3,024	\$ 2,274	\$750	\$ 1,909	0.39
Performing Arts	14,481	15,852	365	\$ 5,545	\$ 4,169	\$ 1,376	\$ 17,734	0.08
University Center	31,770	34,777	800	\$ 12,166	\$ 9,147	\$ 3,019	\$ 16,421	0.18
Student Activities	15,323	16,774	386	\$ 5,868	\$ 4,412	\$ 1,456	\$ 1,554	0.94
Classrooms	15,323	16,774	386	\$ 5,868	\$ 4,412	\$ 1,456	\$ 582	2.50
Classrooms	15,323	16,774	386	\$ 5,868	\$ 4,412	\$ 1,456	\$ 3,974	0.37
Classrooms	37,400	40,940	942	\$ 14,322	\$ 10,768	\$ 3,554	\$ 866	4.10
Classrooms/Labs	68,000	74,437	1,713	\$ 26,040	\$ 19,578	\$ 6,462	\$ 22,106	0.29
<b>Total</b>		<b>224,973</b>	<b>5,176</b>	<b>\$ 78,700</b>	<b>\$ 59,172</b>	<b>\$ 19,528</b>	<b>\$ 65,146</b>	<b>0.30</b>

Note: Estimated annual energy avoided costs is calculated using \$0.12/kWh and \$0.80/therm

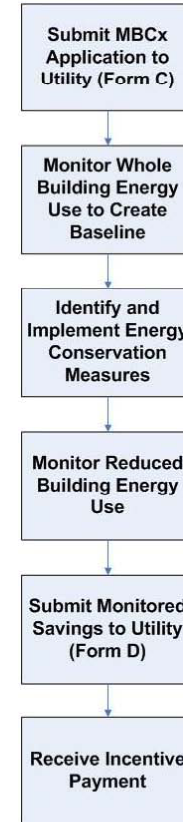
# The MBCx Process

- **Use a benchmarking process to select the best candidate buildings for MBCx.**
- **Install whole building meters to accurately establish the baseline energy use of the building.**
- **Perform functional testing to identify basic operating problems.**
- **Log the energy use and key EMS points in a database.**
- **Utilize database analysis to evaluate the operation of the building and identify potential operational and capital modifications to reduce electricity and gas use.**
- **Implement low and no cost modifications.**
- **Measure actual energy savings and project savings on an annual basis.**

## The MBCx Process

- Document the process thoroughly and perform ongoing monitoring to ensure the persistence of the savings in future years.
- Implement the capital modifications through future funding.

### Basic MBCx Process



\*Note: To receive incentive, project must pass due diligence and a Project Agreement must be signed

## Project Eligibility

- **The campus should take either electricity or natural gas service from a California Investor Owned Utility. The campus may buy commodity electricity or gas from a supplier other than the IOU.**
- **The campus can house a cogeneration plant that does not sell excess power to the utility, or a PV or other renewable plant that is net metered.**
- **Generally, buildings over 25,000 gsf are best candidates for MBCx**

## MBCx Incentive Levels

- **The IOUs will pay a project incentive for qualifying MBCx projects, as follows:**
  - \$0.24/kWh based on actual electric savings
  - \$1.00/therm based on actual gas savings
- **Campus is responsible to pay for meter installation and Commissioning Agent costs**
- **Incentive is paid at the completion of the project and is based on verified savings**

## Campus Commitment

- **The campus must commit to implement all no and low cost measures identified as feasible in the MBCx evaluation with no additional funding from the utility.**
- **The campus must measure before and after energy use to provide solid documentation of annual energy savings.**
- **The campus must commit to make a good faith effort to achieve the energy savings committed to in its proposal.**

## Selection Guidelines for MBCx Sites

The following criteria should be used when selecting good candidate sites for MBCx projects:

- Buildings should have 25,000 square feet of conditioned space or larger. Clusters of multiple, similar buildings located near each other may be considered in order to increase the footprint impacted by MBCx
- Buildings should have some type of mechanical air-conditioning; either served by DX units, dedicated chillers, or chilled water from a central plant.

## Selection Guidelines for MBCx Sites, cont.

- Select buildings with high suspected baseline energy use
  - Buildings with laboratories using fume-hoods, or other spaces requiring elevated ventilation
  - Buildings with data centers
  - Buildings with extended operating hours and/or dense occupancy
  - Where pre-existing metering exists, any building shown to exhibit above average use per square foot

## Selection Guidelines for MBCx Sites, cont.

- The MBCx process can be applied to central plants, when there are suspected energy savings opportunities there. Monitoring will need to be applied to the central plant's energy outputs (chilled water, hot water, steam) as well as its inputs.
- Buildings should have functioning control systems such that energy conservation measures can be implemented and expected to persist.

# Selection Guidelines for MBCx Sites, cont.

Conversely, the following types of sites make poor candidates for MBCx projects:

- Small buildings
- Buildings with limited annual operating hours
- Buildings with low occupancy
- Buildings that are only served by heating and ventilation (or evaporative cooling), with no mechanical air conditioning
- Buildings with non-functioning control systems
- Buildings already operating efficiently, with low energy use intensities (kWh/yr-sf, th/yr-sf)
- Buildings with strict operating requirements, that would prevent modifications being made for efficiency purposes
- Buildings with upcoming major renovations



# CCC/IOU MBCx Workshop

## Form C-1: Building Benchmarking for MBCx cont.

### FORM C-1: Building Benchmarking for MBCx Projects

Historical Building Energy Use

Energy Use Index for the Largest Buildings on Campus

System:

Campus:

Building Ranked by GSP	Building Name	Building Area (GSP)	Building Function	Percent of Building area reporting (GSP) relative to total	Number of occupancy hours (hours)	Building Historical Electricity Use (kWh)	Electric Use Index (kWh/sq ft)	Building Historical Peak Demand (kW)	Building Historical Gas Use (MMBtu)	Historic Gas Use (MMBtu) per sq ft	Historical Steam Use (MMBtu) per sq ft	Historical Steam Use Index (MMBtu/sq ft)	Historical Hot Water Use from Central Plant (MMBtu) per sq ft	Historical Chilled Water Use from Central Plant (MMBtu) per sq ft	Electric Use Index (kWh/sq ft)	Electric Demand Index (kW)	Gas Use Index (MMBtu/sq ft)	Steam Use Index (MMBtu/sq ft)	Hot Water Use Index (MMBtu/sq ft)	Chilled Water Use Index (MMBtu/sq ft)	Gas, Steam, Hot Water and Chilled Water Thermal Energy Use Index (MMBtu/sq ft)	Gas, Steam, Hot Water and Chilled Water Thermal Energy Use Index (MMBtu/sq ft)	Site Total Electric Plus Thermal Energy Use Index (MMBtu/sq ft)	Source - Total Electric Plus Thermal Energy Use Index (MMBtu/sq ft)		
1																										
2																										
3																										
4																										
5																										
6																										
7																										
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16																										
17																										
18																										
19																										
20																										
Total																										
Average																										

Million Btu/sq ft:

1,000  
Btu/sq ft:

Milliwatts cooling:

Building Electric Conversion  
to kWh:  0.415

Building Electric Conversion to  
kBtu:  0.218

## MBCx Project Application

- The campus submits the program application showing building area, building function, and current baseline metered or estimated energy use. This includes electricity and natural gas entering the building, as well as steam, hot water and chilled water delivered to the building from a central plant. Additional metering may be necessary if there are other energy flows, such as chilled water supply to other facilities.

**2009 CCC/IOU Energy Efficiency Partnership Program**

**FORM C: MBCx Project Application Form**  
One Application Per Building or Central System

Please fill in all blue boxes. If more room is required, use Additional Information tab.

District \_\_\_\_\_  
Campus \_\_\_\_\_  
Building Name \_\_\_\_\_  
Person Preparing Application \_\_\_\_\_  
Title \_\_\_\_\_  
Email \_\_\_\_\_  
Date Application Prepared \_\_\_\_\_

**Building Identification**

Please provide the following information for the building or central system included in your proposal. Submit a separate application for each building or central system.

**A. Building/System Description**  
For central systems please provide the information requested for the combined total of all buildings served by the system.

Building Function \_\_\_\_\_  
Building Area (GSF) \_\_\_\_\_  
Please use REVOGSF30 (JC) or equivalent CSU definition of space if available  
Percent of building area requiring 100% outside air ventilation (e.g. laboratories) \_\_\_\_\_  
Fume Hood Count \_\_\_\_\_

Building Type (Structural Characteristics/Features)  
\_\_\_\_\_

Please describe in general how this building is used (e.g., typical operating hours, primary purpose (classroom, lab, etc.)).  
\_\_\_\_\_

Please explain why this building is a good candidate for MBCx. For example, is this building known as a "problem building" or an "energy hog" and why?  
\_\_\_\_\_

How does the energy use index of this building compare with other buildings on campus and other buildings serving a similar function? How did this affect the selection of this building for MBCx? (UC campuses see also Form C-1)  
\_\_\_\_\_

# Form C: MBCx Incentive Application

## 2009 UC/CSU/IOU Energy Efficiency Partnership Program

**2009, 2010-2012 CCC/IOU Energy Efficiency Partnership Program**

**FORM C: MBCx Project Application Form**

One Application Per Building

Please fill in all blue boxes. If more room is required, use Additional Information tab.

District	
Campus	
Building Name	
Campus Contact	
Email	
Phone	
Consultant Contact	
Email	
Phone	
Date Application Prepared	

## Form C: Building/System Description

### A. Building/System Description

For central systems please provide the information

Building Function	<input type="text"/>		
Building Area (GSF)	<input type="text"/>	<input type="text"/>	
Number of Floors	<input type="text"/>	Year Constructed	<input type="text"/>
Fume Hood Count	<input type="text"/>	Typical Operating Hours per Week	<input type="text"/>
Percent of building area requiring 100% outside air ventilation (e.g. laboratories)	<input type="text"/>		

Please explain why this building is a good candidate for MBCx. For example, is this building known as a "problem building" or an "energy hog" and why?

*(to AutoFit the row height to the text, click inside of the text cell, then hit 'Enter')*

How does the energy use index of this building compare with other buildings on campus and other buildings serving a similar function?

*(to AutoFit the row height to the text, click inside of the text cell, then hit 'Enter')*

### B. Central System Equipment Inventory

Please identify control systems.

	DDC	Mix of DDC, Pneumatic, Other	Pneumatic or Other
Air Handlers:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Zone Controls:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Chillers and Boilers (if in bldg):	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

# Form C: Building Metering/Monitoring and Management Inventory

## C. Building Metering/Monitoring/Management Inventory

Select the appropriate status for each of the following meter types and the building. Hot Water, Steam and Chilled Water meters only apply to buildings which receive these energy sources from a *separate* building or central plant. The MBCx program requires that each energy source entering a building (and exiting, for central plants) be metered.

	Building does not receive this energy source.	Meter exists and is already tied into campus EIS.	Meter exists and will be tied into campus EIS.	New meter will be installed and tied into campus EIS
Electricity:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Natural Gas:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hot Water:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Steam:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Chilled Water:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Please identify the existing and/or proposed energy information system(s) (EIS) and how it will interface with meters and equipment (meters should automatically communicate interval energy use to a front end storage device). Also identify the storage capacity (the MBCx program requires the EIS to be able to store and manipulate data for at least 10 years).

*(to AutoFit the row height to the text, click inside of the text cell, then hit 'Enter')*

The MBCx program requires that commissioning agents train campus operators in the revised sequences of operations and usage of newly implemented energy management strategies. Please acknowledge this requirement by checking the box below.

Training and documentation of commissioned systems will be provided to campus operators:

# Form C: Estimated Building Energy Use

## D. Estimated Building Energy Use

Please enter the quantity of energy entering the building. Indicate in the second cell how this is measured or estimated.

Building Use Index

Annual Electricity Use

<input type="text"/>	kWh/yr	<input type="text"/>
----------------------	--------	----------------------

<input type="text"/>	kWh/yr-sq.ft.
----------------------	---------------

On-Peak Electric Demand

<input type="text"/>	kW	<input type="text"/>
----------------------	----	----------------------

<input type="text"/>	W/sq.ft.
----------------------	----------

Annual Natural Gas Use

<input type="text"/>	therm/yr	<input type="text"/>
----------------------	----------	----------------------

<input type="text"/>	therm/yr-sq.ft.
----------------------	-----------------

Does this building serve other buildings with hot water, steam, chilled water or electricity?

<input type="text"/>
----------------------

If yes, explain how this energy will be metered:

<input type="text"/>
----------------------

*(to AutoFit the row height to the text, click inside of the text cell, then hit 'Enter')*

# Form C: Estimated Energy Delivered to the Building from a Separate Plant

**E. Estimated Energy Delivered to the Building from a Separate Plant**

Please enter the quantity of energy delivered to the building from a separate plant. For example, if the building receives chilled water, hot water or steam from a separate plant, enter the quantity here. Please also indicate in the second cell how this is measured or estimated. If the building generates its own chilled water, hot water or steam with the electricity and gas use reported above, do not enter the energy use in these cells.

		Plant Use Index
Annual Steam Use	(choose units)	
<input type="text"/>	<input type="text"/>	<input type="text"/> therm/yr-sq.ft
Annual Hot Water Use		
<input type="text"/>	Million Btu/yr	<input type="text"/> therm/yr-sq.ft.
Annual Chilled Water Use (Electric Chillers)		
<input type="text"/>	<input type="text"/>	<input type="text"/> kWh/yr-sq.ft.
Annual Chilled Water Use (Steam Chillers)		
<input type="text"/>	<input type="text"/>	<input type="text"/> therm/yr-sq.ft.

## Form C: Total Estimated Utility Energy Use

### F. Total Estimated Utility Energy Use

This section calculates the total current annual utility energy use. This includes use directly at the building and energy delivered to the building from a separate plant. If applicable, this estimate assumes a marginal boiler efficiency of 80%, a marginal chiller efficiency of 0.8 kW/ton, and a marginal steam chiller rate of 10 lb. steam per ton-hr.

Total Energy Use Index

Annual Electricity Use

<input type="text"/>	-	<input type="text"/>	kWh/yr
----------------------	---	----------------------	--------

<input type="text"/>	kWh/yr-sq. ft.
----------------------	----------------

On-Peak Electric Demand (Refer to "On-Peak Electric Demand (kW)" worksheet for program definition.)

<input type="text"/>	-	<input type="text"/>	kW
----------------------	---	----------------------	----

<input type="text"/>	W/sq. ft.
----------------------	-----------

Annual Gas Use

<input type="text"/>	-	<input type="text"/>	therm/yr
----------------------	---	----------------------	----------

<input type="text"/>	therm/yr-sq. ft.
----------------------	------------------

# Form C: Projected Utility Energy Savings

## G. Projected Utility Energy Savings

Enter the projected annual utility energy savings, including savings from the building as well as savings from the separate plant, if applicable.

### Projected Annual Electricity Savings

	kWh/yr
0%	Percent of total electricity use projected to be saved.

Electric savings are expected to fall within the following range:  
 5% without potential modifications identified;  
 10% with likely measures identified;  
 15% for particularly inefficient operations already identified.

### On-Peak Electric Demand

	kW
0%	Percent of total summer on-peak demand projected to be saved.

If either the annual or on-peak electric savings fall outside of the anticipated 5-15% range, explain:

*(to AutoFit the row height to the text, click inside of the text cell, then hit 'Enter')*

### Projected Annual Gas Savings

	therm/yr
0%	Percent of total gas use projected to be saved.

Thermal savings are expected to fall within the following range:  
 10% without potential modifications identified;  
 20% with likely measures identified;  
 30% for particularly inefficient operations already identified.

If annual thermal savings fall outside of the anticipated 10-30% range, explain:

*(to AutoFit the row height to the text, click inside of the text cell, then hit 'Enter')*

### Notes

*(to AutoFit the row height to the text, click inside of the text cell, then hit 'Enter')*

# CCC/IOU MBCx Workshop

## Form C: MBCx Budget Proposal and Incentive

**2009, 2010-2012 CCC/IOU Energy Efficiency Partnership Program**

**FORM C: MBCx Budget Proposal and Incentive**

System			
Campus			
Building			
Building Area (GSF)			

Cost Category	In House Costs	Contractor Cost	Total Cost
Monitoring: Install or Upgrade Front End Data System (if required)			\$ -
Monitoring: Implement Building Level Monitoring			\$ -
Monitoring: Implement Equipment Level Monitoring			\$ -
<b>Subtotal Monitoring</b>	\$ -	\$ -	\$ -
Commissioning Measure Identification			\$ -
Commissioning Measure Implementation			\$ -
<b>Subtotal Commissioning</b>	\$ -	\$ -	\$ -
<b>Total MBCx Project Cost</b>	\$ -	\$ -	\$ -
Incentive Requested by University *			\$ -
Funding from University			\$ -

\* Incentive is capped at 80% of project cost.

# CCC/IOU MBCx Workshop

## Form C – MBCx Milestone Schedule



2009, 2010-2012 CCC/IOU Energy Efficiency Partnership Program					
<b>FORM C: MBCx Milestone Schedule</b>					
PLEASE COMPLETE BLUE-SHADED CELLS					
GRAY CELLS FILL AUTOMATICALLY					
Milestone	Responsible	Duration	Planned Date	Note	
Project Opportunity Identified (Building Benchmarking Complete)	Campus / IOU	-			
Form C Project Application (PA) Received by IOU	Campus			Date application submitted to IOU and NAM.	
IOU Due-Diligence Review Complete	NAM	7		Large, complex projects may take longer.	
Management Team Approval	NAM	14		May take longer based on Mgmt Team meeting schedule.	
Project Agreement Executed	IOU	7			
Investigation / Implementation Phase Start	Campus			Expected duration - 7 days.	
Campus Submits Findings / Baseline Report	Campus			Expected duration - 90 days.	
Implementation of Measures Complete	Campus			Expected duration - 90 days.	
Post-Implementation Energy Measurement Complete	Campus			Expected duration - 90 days.	
Draft MBCx Final Report Submitted	Campus			Expected duration - 14 days.	
MBCx Final Report Submitted	Campus			After receipt of IOU comments to draft. Expected duration - 14 days.	
MBCx Systems Manual / Form D Submitted	Campus			After campus training complete. Expected duration - 14 days.	
IOU Post Inspection Report (IR) Complete	IOU	7			
Incentive Paid	IOU	7			

## Form C: On Peak Demand Definitions

There are two peak demand definitions of interest:

**1) Max Peak Demand:** This is the maximum billing demand, which will result in utility bill savings from demand charges.

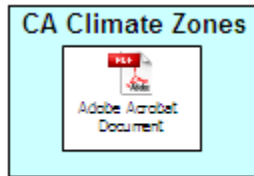
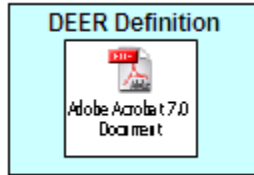
**2) Max Demand (DEER):** For weather dependent measures, this program has adopted the peak demand definition used in the 2005 Database for Energy Efficiency Resources (DEER) update:

Average demand reduction over the nine hours defined below:

- 2 pm - 5 pm on the 3 consecutive weekdays containing the highest temperature of the year.

**Note:** For educational facilities which operate at a significantly reduced use during the time described above (i.e. summer), a *secondary* peak demand should be used. This *secondary* peak demand is calculated the same as described above, but uses the three consecutive days with the highest temperature during the time of the year in which the facility is in full use operation.

For purposes of this program, the dates and associated weather bin data from TMY weather data are summarized below for use in calculations. If using eQUEST or other DOE2 software, these definitions may already be incorporated. **For additional explanation and dates used to calculate *secondary* peak demand savings, the full details can be found in the attached pdf document.**



Climate Zone 01						
Hour	30-Sep		1-Oct		2-Oct	
	WB (°F)	DB (°F)	WB (°F)	DB (°F)	WB (°F)	DB (°F)
15	61	67	62	74	57	60
16	62	69	61	71	55	56
17	61	67	59	66	56	56

Climate Zone 09						
Hour	23-Sep		24-Sep		25-Sep	
	WB (°F)	DB (°F)	WB (°F)	DB (°F)	WB (°F)	DB (°F)
15	69	96	74	102	66	86
16	68	96	74	100	64	82
17	69	94	73	94	62	77

## Approval Process and Criteria



- IOU / NAM performs “due-diligence” review of application
- “Scorecard” process to compare application estimated savings against “benchmarks”
- Savings estimates may be adjusted based on review
- Campus executes Project Agreement prior to starting work

## Approval Process and Criteria

### Criteria for Projected Energy Savings

- **Electricity**
  - 5% standard
  - 10% with good justification
  - 15% with exceptional circumstances
- **Natural Gas**
  - 10% standard
  - 20% with good justification
  - 30% with exceptional circumstances

## The MBCx Project Scope

- **MBCx can be performed by the campus in house, or portions of it can be contracted to an MBCx agent. If an MBCx agent is used, training of campus personnel must be included in the work.**
- **MBCx Requirements and Applications are available on the CCC/IOU website**

<http://www.cccutilitypartnership.com/mbcx.html>

**MBCx Project Requirements**  
Monitoring Based Commissioning (MBCx) Program  
2009-2011 Higher Education / Investor Owned Utility Partnership Programs  
April 2009

Monitoring Based Commissioning

The Higher Education / IOU programs support MBCx for individual buildings or multiple buildings at UC, CSU and CCC campuses. MBCx is a unique combination of building monitoring and commissioning. The monitoring supports the commissioning effort by providing a diagnostic tool, as well as by documenting energy savings in the near term and increasing the persistence of those savings over the long term.

The MBCx process includes the following steps:

- Use a benchmarking process to select the best candidate buildings for MBCx.
- Apply to the Partnership for project approval.
- Install whole building meters to accurately establish the baseline energy use of the buildings.
- Perform functional testing to identify basic operating problems.
- Log the energy use and key EMS points in a database per program guidelines.
- Utilize physical investigation, control sequence review and database analysis to identify and evaluate opportunities to improve the energy efficiency of the building.
- Document potential operational and capital modifications to reduce electricity and gas use.
- Implement low and no cost modifications.
- Measure actual energy savings per program guidelines and project annual savings.
- Document the process in a report and receive Partnership incentive.
- Perform ongoing monitoring to ensure the persistence of the savings in future years.
- Implement the capital modifications through future funding.

This work can be done by the campus in house, or portions of it can be contracted to an MBCx agent. If an MBCx agent is used, training of campus personnel must be included in the work.

This Minimum Program Requirements document describes the basic steps necessary for the implementation of these projects.

Campus Eligibility

The campus should take either electricity or natural gas service from an Investor Owned Utility to qualify for the Higher Education / IOU MBCx Program. The campus may buy commodity electricity or gas from a supplier other than the IOU. The campus can house a cogeneration plant if it does not sell excess power to the utility, or a PV or other renewable plant that is not metered.

Commitment

The campus must commit to implement all recommended no and low cost measures from the MBCx evaluation that it agrees are feasible.

The campus must measure pre and post implementation energy use to provide solid documentation of annual energy savings. The Program incentive will be based on this measured savings.

2009 MBCx Project Requirements 1 April 8, 2009

# MBCx Report Components

### • **MBCx Baseline/Findings Report**

#### 1.1 Introduction

Include summary of all projected costs, savings, and incentives.  
Campus benchmark ranking and bar chart of actual data compared to other campuses; building benchmark data if available

#### 1.2 Facility Description

Area, age, function, schedule, contacts, operational requirements (schedules, occupancy, etc.)  
Available and missing documentation identified

#### 1.3 Scope of Services

Basic MBCx scope and systems being evaluated  
Description of existing controls and trending capacities  
Description of new monitoring capabilities and/or control points to be added

## MBCx Baseline/Findings Report, cont.

1.4 Known issues, improvement opportunities, and potential MBCx measures identified at this stage. Include projected costs and savings, anticipated incentive.

- Summary Table of Proposed Measures, including projected savings, costs, expected incentives
- Discussion of Analysis of the Potential MBCx Measures and Savings Projections

1.5 Historical Energy Use  
Annual Energy Use and Costs to Campus

## MBCx Baseline/Findings Report, cont.

- 1.6 MBCx Plan / Measurement and Verification Plan
  - 1.6.1 Monitoring objectives and requirements
  - 1.6.2 Identify measurement points and planned duration of data collection
  - 1.6.3 MBCx Process
  - 1.6.4 Roles and Responsibilities
  - 1.6.5 Project Schedule
  - 1.6.6 Pre-Functional Test Plan
  - 1.6.7 Functional Test Plan
  - 1.6.8 Operator Training Plan
  - 1.6.8 (Optional Section) Other, non-whole-building M&V methods to be utilized
  - 1.6.9 Plans for M&V Data Analysis (e.g., extrapolation, normalization, adjustment)

## MBCx Baseline/Findings Report, cont.

### 1.7 Baseline Report

- 1.7.1 Baseline system/equipment meter data gathering plan and data summary for each measure. Include the revenue meter numbers that savings will accrue to.
- 1.7.2 Discussion of baseline system/equipment data analysis
- 1.7.3 Assessment and proposed solutions
- 1.7.4 Assessment and analysis of whole-building metering data, if not included in 1.7.2.

# 2. MBCx Final Report

## 2.1 Executive Summary

## 2.2 MBCx Findings/Initiation Report, including baseline analysis (updated if required)

## 2.3 As-installed report

- 2.3.1 Installed energy conservation measures: describe in detail including sequence modifications
- 2.3.2 Discussion of corrected baseline (if necessary)
- 2.3.3 As-installed system/equipment metering data gathering plan and data summary
- 2.3.4 Discussion of energy savings calculations for each measure or package of measures & savings table
- 2.3.5 Provide actual field data that savings are based upon (include whole building interval data when available)
- 2.3.6 ECM persistence recommendations

## 2. MBCx Final Report, cont.

2.4 Discussion of operator training activities

2.5 Discussion of final findings log

2.6 Additional goals and recommendations

2.7 Remaining improvement opportunities

2.8 List any retrofit project identified as a result of the MBCx process

## 3. MBCx System Manual

3.1 MBCx Final Report

3.2 Alarm set points

3.3 Available monitoring points and active trending capabilities

3.4 Control graphics or diagrams

3.5 O&M plan

3.6 Ongoing diagnostics

## MBCx Systems Manual: M&V Plan

### 3.7 M&V Plan

- 3.7.1 General building or plant info & Design intent (current facility requirements)
- 3.7.2 System diagram and descriptions
- 3.7.3 Equipment schedules & control sequences (this includes setpoints)
- 3.7.4 Available monitoring points and recommended trend groups
- 3.7.5 ECM persistence recommendations
- 3.7.6 Updated findings log and action plan
- 3.7.7 Updated benchmarking and baseline data
- 3.7.8 Operator training plans and records
- 3.7.9 Plans for Recommissioning to maintain persistence (15 years).
- 3.7.10 Summary of available as-built records & documentation

## Recommended MBCx Process Schedule

Item	Suggested Timeframe/Duration	Deliverable	
		Report	Partnership Form
<i>Planning Phase</i>			
Use a benchmarking process to select the best candidate buildings for MBCx (optional for CSU and CCC, but recommended)	Prior to application for MBCx Incentive		Form C.1 (optional)
Submit Form C-MBCx Project Application for best candidate buildings			Form C
Project approval from Partnership Management Team			

## Recommended MBCx Process Schedule, cont.

Item	Suggested Timeframe/Duration	Deliverable	
		Report	Partnership Form
<i>Investigation and Implementation Phase</i>			
Install whole building meters to accurately establish the baseline energy use of the building(s). Log energy use and key EMS parameters in a database. Ensure that meters and sensors are calibrated correctly. See Attachment 5 for detailed requirements for baseline measurements.	Baseline data should be collected for up to 3 months. Prior collected trending data can be used if available.		
Perform pre-functional testing to identify basic operating problems. Analyze energy and EMS database to identify operational and capital modifications to reduce electricity and gas use, and electricity demand.	Prior to generation of MBCx Baseline/Findings Report		
Campus Delivers MBCx Baseline/Findings Report to IOU. See Attachment 2 for report components.	Approximately 4 months from Partnership approval (IOU to provide comment, but approval not required to proceed)	Report	

## Recommended MBCx Process Schedule, cont.

### *Investigation and Implementation Phase, contd.*

Item	Suggested Timeframe/Duration	Deliverable	
		Report	Partnership Form
Implementation of selected measures			Measure implementation period can last up to 3 months
Post-functional testing of modified systems			
Document remaining improvement opportunities			
Measure post-implementation energy use. Normalize data and extrapolate to show annual energy savings achieved. See Attachment 5 for detailed requirements for post-implementation measurements.			Post-implementation data should be collected for up to 3 months.

## Recommended MBCx Process Schedule, cont.

<i>Closeout Phase</i>			
Campus delivers Draft MBCx Final Report and to IOU See Attachment 2 for outline.	Approximately 10 months from IOU acceptance of Form C. IOU to review and comment.	Report	
Campus delivers Final MBCx Final Report to IOU		Report	
Provider conducts MBCx Training for Campus (records of Training Sessions to be included in MBCx Systems Manual).			
Provider delivers MBCx Systems Manual to Campus. Campus notifies IOU of receipt of Manual.  See Attachment 2 for outline		Report	
Campus submits Form D-MBCx Summary Report to IOU	IOU to Review and Approve		Form D
Campus receives MBCx Incentive Payment	Approximately 11 months from IOU Acceptance of Form C		

## Functional Testing, Evaluation and Implementation

- **Perform functional testing for the major mechanical equipment in the building. Identify deficiencies in operations and correct deficiencies to bring building up to a minimal operating point.**
- **Utilize the findings from the functional testing and evaluations of the energy use load profile and EMS point logs as the basis for identifying ways to improve the efficiency of the building.**
- **Implement the low and no cost measures identified in the evaluation phase.**

## General Types of Building Systems to be Investigated

Central Plant(s) including the following general types of equipment:

- Chillers
- Cooling Towers
- Boilers
- Pumps
- Control Systems including VFDs and sequences of control
- Waterside Economizers

## General Types of Building Systems to be Investigated, cont.

### Central Air Handler(s)

- Fans
- Chilled water coils and valves
- Hot water coils and valves
- Dampers
- Control Systems, including VFDs, Outside Air Economizer and other sequences of control

## General Types of Building Systems to be Investigated: Zonal HVAC

### Zonal HVAC

- Depending upon the number of zones, zonal equipment may initially be evaluated by Provider by sampling, and the extent of problems will determine whether all zones need to be evaluated and whether any discovered problems are assumed to be global, and that solutions may be applied globally
- HVAC delivery to the Space (air and/or water distribution, whether dual duct, VAV terminals with re-heat, hydronic, etc.)
- Control Systems and sequences of control for HVAC delivery and zonal temperature control

# General Types of Building Systems to be Investigated, cont.

- Major Unitary Systems
  - Rooftop Package Units (15 Tons or over)
  - Controls
- Lighting Systems
  - Interior Lighting Controls
  - Exterior Lighting Controls
- Refrigeration Systems
  - Controls
- Domestic Hot Water Systems
  - Heaters/Boilers
  - Controls
- Process Controls

# Typical Measures

A wide range of energy efficiency measures may be implemented under the Program. Most commonly, energy efficiency measures will apply to the following system components: air handlers, chillers, cooling towers, economizers, boilers, lighting, and controls. While measures will be determined on a site-by-site basis, the Program's common MBCx measures include:

- Scheduled Loads
  - Equipment Scheduling: Time of Day
  - Equipment Scheduling: Optimum Start-Stop
  - Equipment Scheduling: Lighting Controls
- Economizer/Outside Air Loads
  - Economizer Operation: Inadequate Free Cooling
  - Over-Ventilation
  - Demand Controlled Ventilation

# Typical Measures, cont.

- Control Problems
  - Simultaneous Heating and Cooling
  - Sensor/Thermostat Calibration and/or Optimal Relocation
  - Hunting and Loop Tuning
  - Damper/Valve Actuator Calibration
  - Zone Rebalancing
  
- Controls: Setpoint Changes
  - Duct Static Pressure Setpoint
  - Piping Differential Pressure Setpoint
  - Reduction of VAV Box Minimum Setpoint
  - Implementation/Adjustment of Heating/Cooling, and Occupied/Unoccupied Space Temperature Setpoints

# Typical Measures, cont.

- Controls: Reset Schedules
  - HW Supply Temperature Reset or HW Plant Scheduling
  - CHW Supply Temperature Reset
  - CW Supply Reset for Chiller Efficiency Optimization (Newer VFD Chillers)
  - Supply Air Temperature Reset: Cooling and Heating
  - Duct Static Pressure Reset
- Equipment Efficiency Improvements / Load Reduction
  - De-Lamping of Over-Lit Spaces
  - Pump Discharge Throttled, Over-Pumping and Low Delta T–Trim Impeller
- Variable Frequency Drives (VFD)
  - VFD Retrofit – Fans
  - VFD Retrofit - Pumps
- Equipment Maintenance
  - Leaking Valves (hot water or chilled water valves)
  - Actuator / Damper Operation

# Typical Measures, cont.

The goal of the MBCx program is to implement the following types of measures:

- Fix problems with existing controls.
  - Enhance the control and operation of existing equipment.
  - Make limited repairs/upgrades to existing equipment to make it run more efficiently.
- 
- MBCx definition is somewhat flexible

Recommendations to improve the facility performance, such as indoor air quality issues, should be noted in the MBCx Final Draft Report even if there are no energy savings associated with them. Minimum ventilation requirements must be maintained per code.

# International Performance Measurement and Verification Protocol

- **IPMVP Options**

- **A. Retrofit Isolation: Key Parameter Measurement**
- **B. Retrfofit Isolation: All Parameter Measurement**
- **C. Whole Facility**
- **D. Calibrated Simulation**

# Measurement Protocol Guidelines

## MBCx 2009-2011 Higher Education/ IOU Partnership

MBCx projects should quantify energy savings through procedures in accordance with IPMVP. The preferred IPMVP approach is the Option C – Whole Building method, although other Options can be used with justification. The use of alternative IMPVP Options does not eliminate the need for whole building metering of all utilities.

The following specific accommodations are required for the use of Option C in the Partnership program:

# Measurement Protocol Guidelines, cont.

Typical Savings: Expected building energy savings should typically be more than 5% of the base-year energy use.

Independent Variables: In order to establish and adjust baseline energy use, the following variables should be tracked at a minimum:

- Outside Air temperatures - hourly or daily average data
- Building operating hours (e.g., weekday hours and weekend hours for both in-session and out-of-session periods)
- Occupancy – whether the university is in-session or out-of-session (separate regression models may need to be developed for these periods)

Additionally, data for potential special adjustments should also be captured, including:

- Major changes in building plug loads (e.g., a computer monitor upgrade project)
- Any batch processing occurring and associated hours

## Metering Plan



- **Develop a metering plan to measure whole building energy use, submeter specific loads as necessary, and to account for central plant energy delivered to the building.**
- **Develop an M&V plan to establish a building energy use adjusted baseline, including central plant energy use associated with the building, and to document energy use after implementation of low and no cost measures.**

### Metering Plan – cont.

- **Define time periods to collect adjusted baseline and post implementation energy use to allow accurate projection of annual building energy use for the adjusted baseline and for the post implementation energy use. Typical monitoring periods should be three months.**
- **Install whole building metering conforming to the M&V plan to measure all electric, gas, steam, hot water and chilled water inputs to the building. Install submeters as necessary to break out particular equipment energy use.**
- **Calibrate all new and existing meters. Verify correct collection of metered data in the database program.**

## CCC/IOU MBCx Workshop

# Measurement Protocol Guidelines: Measurement Period

### Minimum Measurement Period to Establish Baseline

	<b>Buildings <u>without</u> pre-existing metering (metering capability to be installed with MBCx project).</b>	<b>Buildings <u>with</u> pre-existing metering or building level monthly records of all main energy uses (metering capability to be upgraded with MBCx project).</b>	<b>Buildings <u>with</u> pre-existing metering and <u>full</u> trending capability.</b>
kWh, kW	Three consecutive months of whole building interval electric data (and CHW if served by plant not on bldg meter) not including January or July. Annualized using independent variables above.	Four weeks of whole building interval electric data (and CHW if served by plant not on bldg meter), including at least two weeks at full occupancy. Annualized by reconciling with one year historical usage data.	Baseline may be established with at least three consecutive months excluding January and July of existing data from pre-existing energy information system. Annualized using above independent variables if necessary.

## Measurement Protocol Guidelines: Measurement Period, cont.

	<b>Buildings <u>without</u> pre-existing metering (metering capability to be installed with MBCx project).</b>	<b>Buildings <u>with</u> pre-existing metering or building level monthly records of all main energy uses (metering capability to be upgraded with MBCx project).</b>	<b>Buildings <u>with</u> pre-existing metering and <u>full trending</u> capability.</b>
Gas, Hot Water, Steam	Three consecutive months of whole building interval gas, (and HW and steam if served by plant not on bldg meter) not including January or July. Annualized using independent variables above.	Four weeks of whole building interval gas, (and HW and steam if served by plant not on bldg meter) from either fall or spring season, including at least two weeks at full occupancy. Annualized by reconciling with one year historical usage data.	Baseline may be established with at least three consecutive months excluding January and July of existing data from pre-existing energy information system. Annualized using above independent variables if necessary.

After MBCx measure implementation, the savings reporting period should be at least three months as in the first column above, and ideally in the season opposite the baseline (i.e., if baseline established in the spring, post-implementation measurement period in the fall).

## Database Program Requirements

- **Web-enabled commercial database program specifically designed for the tracking and evaluation of energy use meters and EMS points.**
- **Capability to log, store and manipulate energy use information for every major building on campus for at least 10 years. These capabilities are beyond the capacity of many energy management systems.**
- **Capability to communicate with existing campus energy management systems to allow logging of points from the EMS for use in the database program.**
- **Allow multiple ways to view and display data, including with data visualization software.**

# Btu Meter Technology

**Table 5.4.** Common Water Metering Technologies and Key Criteria

Criteria	Positive Displacement	Orifice	Venturi	Turbine	Vortex Shedding	Ultrasonic Dop/TT
Accuracy	Good	Moderate	Good	Good	Good	Moderate
Turndown Ratio	10:1	<5:1	<5:1	10:1	20:1	10:1 / 20:1
Repeatability	Good	Good	Good	Low	Very Good	Good
Installation Ease	Easy	Easy	Moderate	Challenging	Moderate	Very Easy
Pressure loss	Medium	Moderate	Low	Moderate	Low	None
Recalibration Needs	Infrequent	Frequent	Infrequent	Frequent	Infrequent	Moderate
Capital Cost	Low	Low	Moderate	Moderate	Moderate	High
Installed Cost	Moderate	Low	Moderate	Moderate	Moderate	Low
Maintenance Cost	Low	High	Moderate	Moderate	Low	Low

# Steam Meter Technology

**Table 5.2.** Common Steam Metering Technologies and Key Criteria

Criteria	Orifice	Annubar	Turbine	Vortex Shedding
Accuracy	Moderate	Good	Good	Good
Turndown Ratio	<5:1	5:1	10:1	20:1
Repeatability	Good	Good	Low	Very Good
Installation Ease	Easy	Easy	Challenging	Moderate
Pressure loss	Moderate	Low	Moderate	Low
Recalibration Needs	Frequent	Infrequent	Frequent	Infrequent
Capital Cost	Low	Low	Moderate	Moderate
Installed Cost	Low	Low	Moderate	Moderate
Maintenance Cost	High	Low	Moderate	Low

# Natural Gas Meter Technology

**Table 5.1.** Common Natural Gas Metering Technologies and Key Criteria

Criteria	Positive Displacement	Orifice	Venturi	Annubar	Turbine	Vortex Shedding
Accuracy	Good	Moderate	Good	Good	Good	Good
Turndown Ratio	10:1	<5:1	<5:1	10:1	10:1	20:1
Repeatability	Good	Good	Good	Very Good	Low	Very Good
Installation Ease	Easy	Easy	Moderate	Easy	Challenging	Moderate
Pressure loss	Medium	Moderate	Low	Low	Moderate	Low
Recalibration Needs	Infrequent	Frequent	Infrequent	Infrequent	Frequent	Infrequent
Capital Cost	Low	Low	Moderate	Low	Moderate	Moderate
Installed Cost	Moderate	Low	Moderate	Low	Moderate	Moderate
Maintenance Cost	Low	High	Moderate	Low	Moderate	Low

## Reporting, Documentation and Ongoing Steps

- Follow the M&V plan to create the post implementation energy use.
- Subtract the post implementation energy use from the Adjusted Baseline to calculate annual energy savings.
- Report these results in the program spreadsheet to document energy savings, including a comparison of savings with original program commitments.
- Document the MBCx process through the reporting procedures outlined in the standard MBCx Scope of Work
- *Ongoing:* Program the database to evaluate data collected in the following years to alarm operators when energy use patterns or other indicators show that operations have changed or that energy use is drifting up.

**MBCx Project Reporting Summary for Program Database**  
CCC-IOU 2009 Energy Efficiency Partnership Program

Return to: <mailto:andres@cccweb.com>. Call with questions to 415-896-0300.  
Name of Campus Representative Completing this Form \_\_\_\_\_

Contact Information for Campus Representative Completing this Form \_\_\_\_\_

District and Campus \_\_\_\_\_

Building or System Name \_\_\_\_\_

Primary/Building Function \_\_\_\_\_

Gross Building Area (excluding parking lots and other unconditioned spaces) \_\_\_\_\_ GSF

Area of building that requires 100% outside air ventilation \_\_\_\_\_ GSF

Number of laboratory time heads in the building \_\_\_\_\_

What was the scope of the retro-commissioning project? Check all systems and building components that were addressed.

<input type="checkbox"/> Cooling plant	<input type="checkbox"/> Envelope	<input type="checkbox"/> Other - Please describe below:
<input type="checkbox"/> Heating plant	<input type="checkbox"/> Lighting	
<input type="checkbox"/> Air handling & distribution	<input type="checkbox"/> Plug loads	
<input type="checkbox"/> Terminal units		

What energy uses were targeted?

<input type="checkbox"/> Electricity	<input type="checkbox"/> Chilled water	<input type="checkbox"/> Other - Please describe below:
<input type="checkbox"/> Natural gas	<input type="checkbox"/> Steam	
<input type="checkbox"/> Hot water		

What energy saving measures did you anticipate finding through the MBCx process?

Which of the following types of monitoring were implemented? Check all that apply.

<b>Energy and Power Meters</b>	<b>Temperature and Pressure Sensors</b>	<b>Flow Meters</b>
<input type="checkbox"/> Whole building electricity meter	<input type="checkbox"/> Hot water temperature(s)	<input type="checkbox"/> Hot water flow meter
<input type="checkbox"/> Whole building gas meter	<input type="checkbox"/> Chilled water temperature(s)	<input type="checkbox"/> Chilled water flow meter
<input type="checkbox"/> Pump power (e.g. ammeter, kW meter)	<input type="checkbox"/> Supply air temperature(s)	<input type="checkbox"/> Other - Please describe below:
<input type="checkbox"/> Fan power (e.g. ammeter, kW meter)	<input type="checkbox"/> Return air temperature(s)	<b>Status Measurements</b>
<input type="checkbox"/> Chiller power (e.g. ammeter, kW meter)	<input type="checkbox"/> Outside air temperature	<input type="checkbox"/> Fan Status/Speed
<input type="checkbox"/> Hot water BTU meter	<input type="checkbox"/> Differential pressure(s)	<input type="checkbox"/> Pump Status/Speed
<input type="checkbox"/> Chilled water BTU meter		
<input type="checkbox"/> Steam BTU meter		

Describe the data collected during the baseline measurement period. How were these data used to adjust the facility's annual historical energy use baseline?

What energy saving commissioning measures were implemented? Where? (Use measure categories listed on Input Page 2.)

How was the annual energy savings calculated from the measured data? (Select from pull-down menu)

Please describe below:

What problems did the monitoring allow you to identify that may not have been identified otherwise?

List any related projects identified as a result of the MBCx project.

List any non-energy benefits of the MBCx project, or other comments on the project.

# CCC/IOU MBCx Workshop

## Form D - MBCx Project Reporting Summary for Program Database CCC-IOU 2009 Energy Efficiency Partnership Program

MBCx Project Reporting Summary for Program Database			
CCC/IOU 2009, 2010-2012 Energy Efficiency Partnership Program			
Return to <a href="mailto:mike_anderson@newcomb.cc">mike_anderson@newcomb.cc</a> . Call with questions to 415-896-0300.			
Name of Campus Representative Completing this Form			
Contact Information for Campus Representative Completing this Form			
District and Campus			
Building or System Name			
Primary Building Function			
Gross Building Area (excluding parking lots and other unconditioned spaces)			GSF
Area of Building that requires 100% outside air ventilation			GSF
Number of laboratory fume hoods in the building			
<b>What was the scope of the retrocommissioning project? Check all systems and building components that were addressed.</b>			
<input type="checkbox"/> Cooling plant	<input type="checkbox"/> Envelope	<input type="checkbox"/> Other - Please describe below:	
<input type="checkbox"/> Heating plant	<input type="checkbox"/> Lighting		
<input type="checkbox"/> Air handling & distribution	<input type="checkbox"/> Plug loads		
<input type="checkbox"/> Terminal units			

# CCC/IOU MBCx Workshop

## Form D - Input Page 1, cont.

**What energy uses were targeted?**

- |                                      |  |   |
|--------------------------------------|--|---|
| <input type="checkbox"/> Electricity | <input type="checkbox"/> Chilled water | <input type="checkbox"/> Other - Please describe below:<br><br> |
| <input type="checkbox"/> Natural gas | <input type="checkbox"/> Steam         |   |
| <input type="checkbox"/> Hot water   |  |   |

**What energy saving measures did you anticipate finding through the MBCx process?**

**Which of the following types of monitoring were implemented? Check all that apply.**

**Energy and Power Meters**

- Whole building electricity meter
- Whole building gas meter
- Pump power (e.g. ammeter, kW meter)
- Fan power (e.g. ammeter, kW meter)
- Chiller power (e.g. ammeter, kW meter)
- Hot water BTU meter
- Chilled water BTU meter
- Steam BTU meter

**Temperature and Pressure Sensors**

- Hot water temperature(s)
- Chilled water temperature(s)
- Supply air temperature(s)
- Return air temperature(s)
- Outside air temperature
- Differential pressure(s)

**Flow Meters**

- Hot water flow meter
- Chilled water flow meter
- Other - Please describe below:

**Status Measurements**

- Fan Status/Speed
- Pump Status/Speed

**Describe the data collected during the baseline measurement period. How were these data used to adjust the facility's annual historical energy use baseline?**

# CCC/IOU MBCx Workshop

## Form D - Input Page 1, cont.

What energy saving commissioning measures were implemented? When? (Use measure categories listed on Input Page 3.)

How was the annual energy savings calculated from the monitored data? (Select from pull-down menu.)

Please describe below:

What problems did the monitoring allow you to identify that may not have been identified otherwise?

List any retrofit projects identified as a result of the MBCx project.

List any non-energy benefits of the MBCx project, or other comments on the project.

# CCC/IOU MBCx Workshop

## Form D – Input Page 2: Building/Process Total Energy Use

### MBCx Project Reporting Summary for Program Database

CCC/IOU 2009, 2010-2012 Energy Efficiency Partnership Program

**INSTRUCTIONS:** Fill in ALL blue fields. If a field does not apply, choose 'N/A' from the drop-down menu. If the facility's boiler and chiller marginal efficiencies are not known, choose the standard marginal efficiencies available in the drop-down menus. For all peak demand inputs, refer to the 'On-Peak Demand (kW)' tab for the program definition. For the peak chilled water demand from electric chillers at a central plant, include only the portion of the demand that actively uses on-peak electricity; do not include any portion handled by a TES system.

#### Building/Process Total Energy Use

##### A. Historical Baseline From Proposal

Building Electricity Use - <i>Do not include central plant use</i>	<input type="text"/>	kWh/yr
Peak Demand - <i>Do not include central plant use</i>	<input type="text"/>	kW
Building Natural Gas Use - <i>Do not include central plant use</i>	<input type="text"/>	th/yr
Steam from Central Plant	<input type="text"/>	Million Btu/yr
Hot Water from Central Plant	<input type="text"/>	Million Btu/yr
Chilled Water from Central Plant	<input type="text"/>	ton-hr/yr
Peak CHW Demand from Electric Chillers at Central Plant	<input type="text"/>	tons <i>(do not include any portion of the load handled by a TES system)</i>

##### B. Revised Baseline after Monitoring

Building Electricity Use - <i>Do not include central plant use</i>	<input type="text"/>	kWh/yr
Peak Demand - <i>Do not include central plant use</i>	<input type="text"/>	kW
Building Natural Gas Use - <i>Do not include central plant use</i>	<input type="text"/>	th/yr
Steam from Central Plant	<input type="text"/>	Million Btu/yr
Hot Water from Central Plant	<input type="text"/>	Million Btu/yr
Chilled Water from Central Plant	<input type="text"/>	ton-hr/yr
Peak CHW Demand from Electric Chillers at Central Plant	<input type="text"/>	tons <i>(do not include any portion of the load handled by a TES system)</i>

##### C. Energy Use after Initial MBCx Modifications

Building Electricity Use - <i>Do not include central plant use</i>	<input type="text"/>	kWh/yr
Peak Demand - <i>Do not include central plant use</i>	<input type="text"/>	kW
Building Natural Gas Use - <i>Do not include central plant use</i>	<input type="text"/>	th/yr
Steam from Central Plant	<input type="text"/>	Million Btu/yr
Hot Water from Central Plant	<input type="text"/>	Million Btu/yr
Chilled Water from Central Plant	<input type="text"/>	ton-hr/yr
Peak CHW Demand from Electric Chillers at Central Plant	<input type="text"/>	tons <i>(do not include any portion of the load handled by a TES system)</i>

# CCC/IOU MBCx Workshop

## Form D, Input Page 2 cont.

### Building/Process Energy Savings

#### D. Measured Savings from MBCx Project (B minus C from above.)

Building Electricity Savings (Not including central plant use)	<input type="text"/>	kWh/yr
Peak Demand (Not including central plant use)	<input type="text"/>	kW
Building Natural Gas Savings (Not including central plant use)	<input type="text"/>	th/yr
Steam Savings from Central Plant	<input type="text"/>	Million Btu/yr
Hot Water Savings from Central Plant	<input type="text"/>	Million Btu/yr
Chilled Water Savings from Central Plant	<input type="text"/>	ton-hr/yr
Peak CHW Demand Savings from Electric Chillers at Central Plant	<input type="text"/>	tons

Percent CHW Savings from each Chiller Type:	<i>Electric Chiller</i>	<i>Steam Chiller</i>
	100%	0%

Estimate the equivalent electricity or fuel savings at the central plant. Marginal efficiencies for chillers and boilers should be used. If these are not available, use average efficiencies.

Fuel Savings at Central Plant from Saving Steam	<input type="text"/>	th/yr of gas
Fuel Savings at Central Plant from Saving Hot Water	<input type="text"/>	th/yr of gas
Electricity Savings at Central Plant from Saving Chilled Water	<input type="text"/>	kWh/yr of electricity
Fuel Savings at Central Plant from Saving Chilled Water	<input type="text"/>	th/yr of gas
Peak Demand Savings from Electric Chillers at Central Plant	<input type="text"/>	kW

Boiler Efficiency	<input type="text"/>	Percent
Electric Chiller Efficiency	<input type="text"/>	kW/ton
Steam Chiller Efficiency	<input type="text"/>	lb-steam/ton-hr

#### Net Utility Savings Including Central Plant (if any) \*

##### E. Savings at the Meter

	Building Savings		Central Plant Savings	=	Total Savings
Annual Electricity Savings	<input type="text"/>	kWh/yr	<input type="text"/>		<input type="text"/>
Peak Demand Savings	<input type="text"/>	kW	<input type="text"/>		<input type="text"/>
Annual Natural Gas Savings	<input type="text"/>	th/yr	<input type="text"/>		<input type="text"/>

\* Campuses with cogeneration report electricity and gas use equivalent to a conventional central plant.

##### F. Actual Project Cost

	Contracted Out	In House Costs	Total Costs
Metering and Monitoring (Meters and installation, trending software, and training on meters and	\$50,000	\$25,000	\$75,000
Baseline and Commissioning (Establishing baseline, commissioning activities, reporting, and		\$12,500	\$12,500
<b>Total Cost</b>			<b>\$87,500</b>

# CCC/IOU MBCx Workshop

## Form D – Input Page 3

MBCx Project Reporting Summary for Program Database			Commissioning Measures Implemented																		
CCC/IOU 2009, 2010-2012 Energy Efficiency Partnership Program			Design, Installation, Retrofit, Replacement				Operations & Control									Maintenance					
Please enter the <b>number</b> of Component-Measures implemented in this project in the applicable green cell.			Design change	Installation modifications	Retrofit/equipment replacement	Other	Implement advanced reset	Start/Stop (environmentally determined)	Scheduling (occupancy determined)	Modify setpoint	Equipment staging	Modify sequence of operations	Loop tuning	Behavior modification/manual changes to operations	Other	Calibration	Mechanical fix	Heat transfer maintenance	Filtration maintenance	Other	
Component being Commissioned			D1	D2	D3	D4	OC1	OC2	OC3	OC4	OC5	OC6	OC7	OC8	OC9	M1	M2	M3	M4	M5	
HVAC (combined heating and cooling)	Y																				
Cooling plant	C																				
Heating plant	H																				
Air handling & distribution	A																				
Terminal units	T																				
Lighting	L																				
Envelope	E																				
Plug loads	P																				
Facility-wide (e.g. EMCS or utility)	F																				
Other	O																				

Data format from Evan Mills, Lawrence Berkeley National Laboratory

# Questions?



For more information check the Partnership Web Site at:

**[www.cccutilitypartnership.com](http://www.cccutilitypartnership.com)**

## CCC/IOU MBCx Workshop

# Contact Information – *how can we help you?*

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