



PECI™

Energy for Change™

Building Optimization Analysis (BOA) Tool Training

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Training Objectives

- Use the BOA Tool to calculate energy savings for RCx measures
- Determine BOA Tool applicability for project-specific RCx measures
- Integrate the BOA Tool into your utility RCx program work
- Know who to contact for more information about the BOA Tool

Agenda

- History
- Overview of Tool
- Use the BOA Tool
- Tool applicability
- Tool integration with utility RCx programs
- Resources

BOA Tool History

- Evaluations of recent RCx programs said “simplify”
- Focus on most common lower-savings measures from the 2006-2009 programs
- SCE developed first set of measures, with AESC, PEGI, ASW, and SoCal Gas
- PG&E developed second set of measures, with PEGI, NAM, and AESC



Overview

- Free spreadsheet-based Tool, sponsored by California utilities
- For use in California utility RCx programs (PG&E, SCE, SoCal Gas, SDG&E, SMUD)
- BOA Tool calculates energy and demand savings
 - Does not calculate implementation costs
 - Does not prescribe M&V methodology for measures

Overview (Cont'd)

- Requirement to use the BOA Tool?
 - Expect that you should use the Tool where it is applicable
- Approved for use immediately (12 measures)
 - Final BOA Tool with all 13 measures will be available by September 30, 2010
 - Occupancy sensor measure is currently being developed

Overview (Cont'd):

11 HVAC Measures Included in Tool

- Airside
 - Reduce supply fan operating schedule
 - Add supply air temperature reset
 - Reduce supply duct static pressure
 - Reset supply duct static pressure
 - Add supply fan VFD
 - Adjust zone temperature deadband
 - Adjust airside economizers
- Waterside
 - Add boiler lockout
 - Add chilled water supply temperature reset
 - Add condenser water supply temperature reset
 - Add chilled water pump VFD

Overview (Cont'd): One Lighting Measure Included in Tool

- Reduce lighting operating schedule
- More HVAC than lighting measures
 - Most CA utility RCx measures are HVAC-related



Using the BOA Tool

- Excel® spreadsheet-based tool
 - Uses functions embedded in Excel®
 - No macros!
 - Worksheets are locked as necessary
 - Except for inputs

Hackers beware!



... tool users rejoice?

BOA Tool Layout

- A series of worksheets:
 - Instructions
 - Tool Applicability
 - General Project Input
 - ... then the 12 measure worksheets



Can rename and/or copy the measure tabs
as needed, to suit project conditions

Key Things to Know

- Tool can be used for calculating energy and demand savings
- Tool is not designed to:
 - Calculate \$ savings
 - Calculate costs
 - Determine M&V requirements
 - Analyze trend data
 - Be used outside of California utility RCx programs

Key Things to Know

- Tool is for use with low savings measures
 - $< 75,000$ kWh and $< 5,000$ therms
 - **This makes up about 75% of the measures seen in utility RCx programs**



Key Things to Know

- Tool applies to certain building types
 - Not all commercial building types are covered (yet)
- Tool calculates savings by applying inputs to pre-calculated savings factors
 - Obtained from DOE-2.2 runs using DEER prototype models
 - Pre-calculated values can be seen by unhiding the “db” worksheets in the tool

High-level Tool Applicability

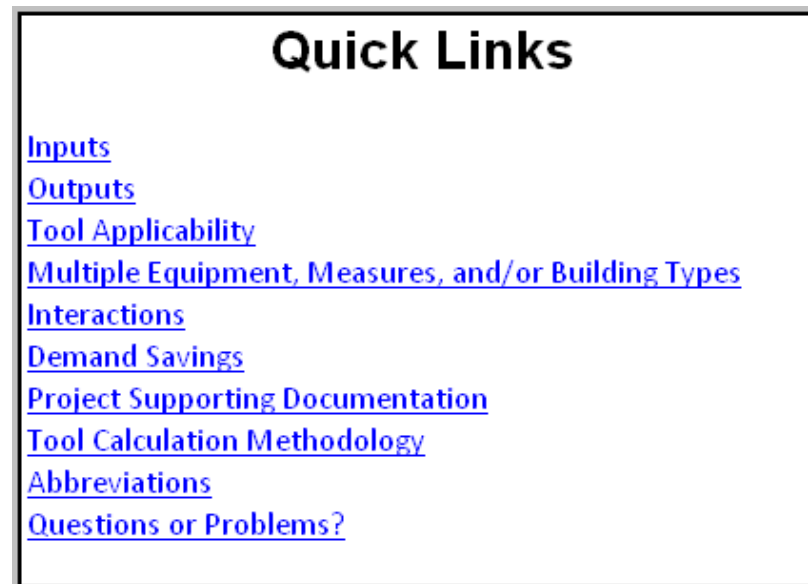
“Tool Applicability” worksheet, a snapshot:

BOA Tool Applicability										
Measure	Measure Worksheet Name (click to go to worksheet)	Building Type								
		Education - Community College	Education - Primary School	Education - Secondary School	Education - University	Hospital	Hotel	Office	Retail - 3-Story	Retail - Single Story
<i>HVAC Airside</i>										
Reduce supply fan operating schedule	SF Schedule	X	X	X	X		X	X	X	X
Adjust airside economizers	Economizer					X		X	X	
Adjust zone temperature deadband	Zone Temp Deadband				X	X	X	X	X	
Add supply air temperature setpoint reset strategy	SAT Reset				X	X	X	X	X	
Reduce supply duct static pressure setpoint	DSP Reduction			X		X	X	X	X	
Add supply duct static pressure setpoint reset strategy	DSP Reset			X		X	X	X	X	
Add / restore supply fan VFD	SF VFD			X		X	X	X	X	
<i>HVAC Waterside</i>										
Add / optimize boiler lockout	Boiler LO			X		X	X	X	X	
Add chilled water supply temperature setpoint reset strategy	CHWST Reset				X	X	X	X	X	
Add condenser water supply temperature setpoint reset strategy	CWST Reset			X		X	X	X	X	
Add / restore chilled water pump VFD	CHW pump VFD			X		X	X	X	X	
<i>Lighting</i>										
Reduce lighting operating schedule	Lighting Schedule				X	X	X	X	X	

Use “General Project Input” tab for more detailed view

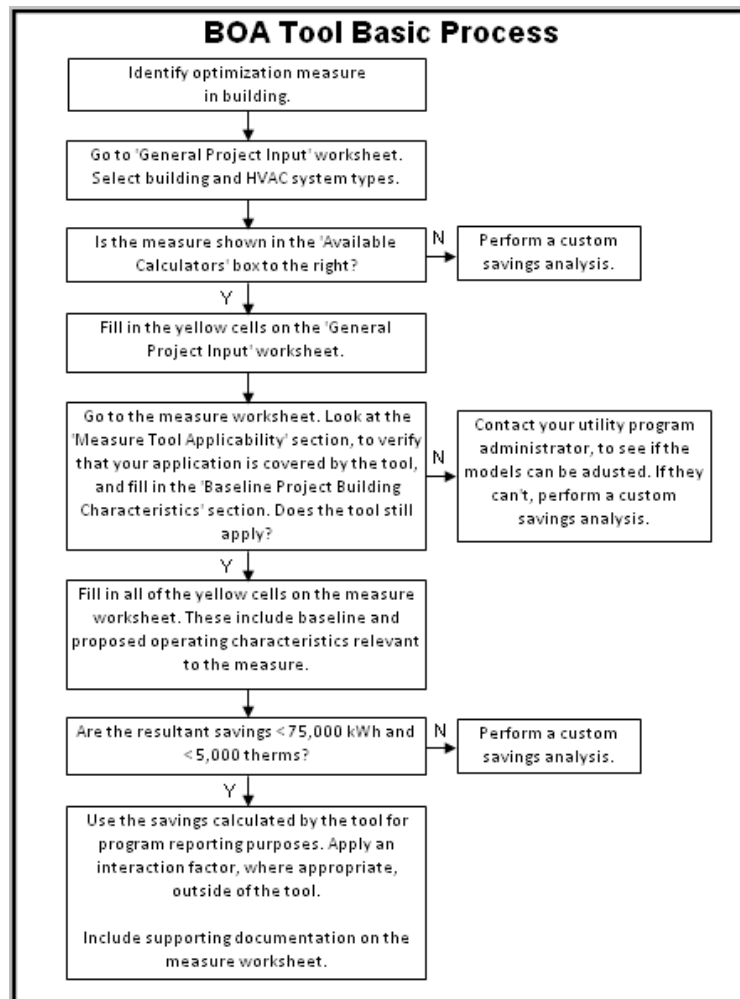
“Instructions” Worksheet

- From the basics to the details



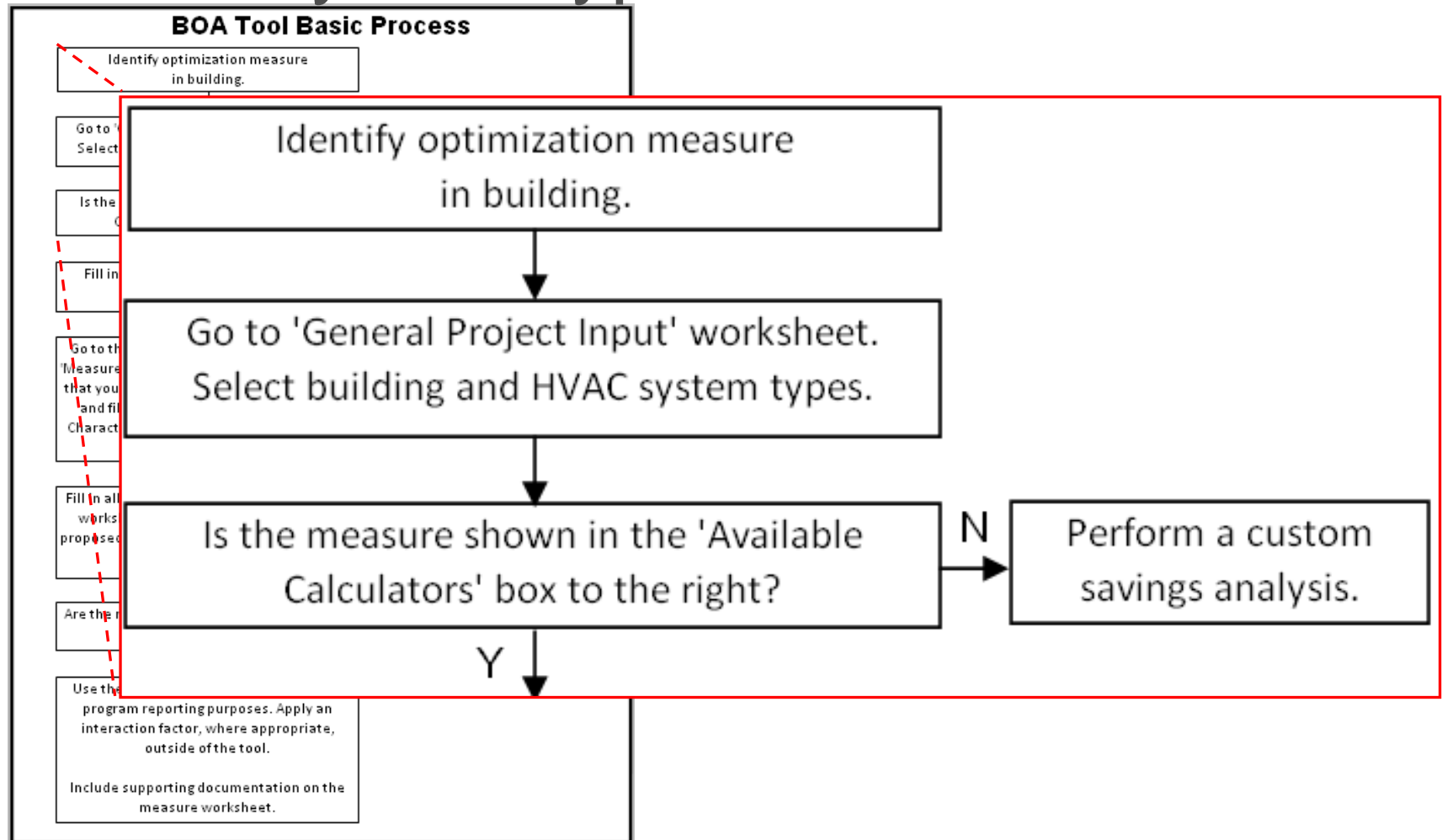
- Visit this worksheet first with questions
 - Use the Quick Links hyperlinks to navigate

“Quick Start” Flowchart on Instructions Worksheet



From measure identification through savings calculation

First step: does the Tool cover your measure, building type, and HVAC system type?



Tool Applicability

“General Project Input” worksheet:

Select from drop-down lists ...

General Inputs	
Building Type	Hospital
Primary Ventilation System Type	VAV AHU / RTU w/ zone reheat
Primary Cooling System Type	Water-Cooled Chiller(s)
HVAC Heating System Type	Natural Gas Water Boiler

... then look to box to right for available calculators

Available calculators based on selected building and system types:

SF Schedule - Not Applicable
 Lighting Schedule
 Boiler Lockout
 Economizer
 Zone Temperature Deadband
 SAT Reset
 DSP Reduction
 DSP Reset
 SF VFD
 CHWST Reset
 CWST Reset
 CHW Pump VFD

Start Your Engines

- Open the BOA Tool on your computer
- Use the Tool to answer the questions in the following three exercises



<http://itodyaso.files.wordpress.com/2009/09/asleep-at-computer.jpg>

Anyone still awake out there?

Exercise #1

Does the Tool apply for the following?

- Building type = University
- Measure = Chilled water supply temperature reset
- Variable air volume air handlers
- Water-cooled chillers
- Natural gas water boiler

Exercise #1 Debrief

- Answer = Yes

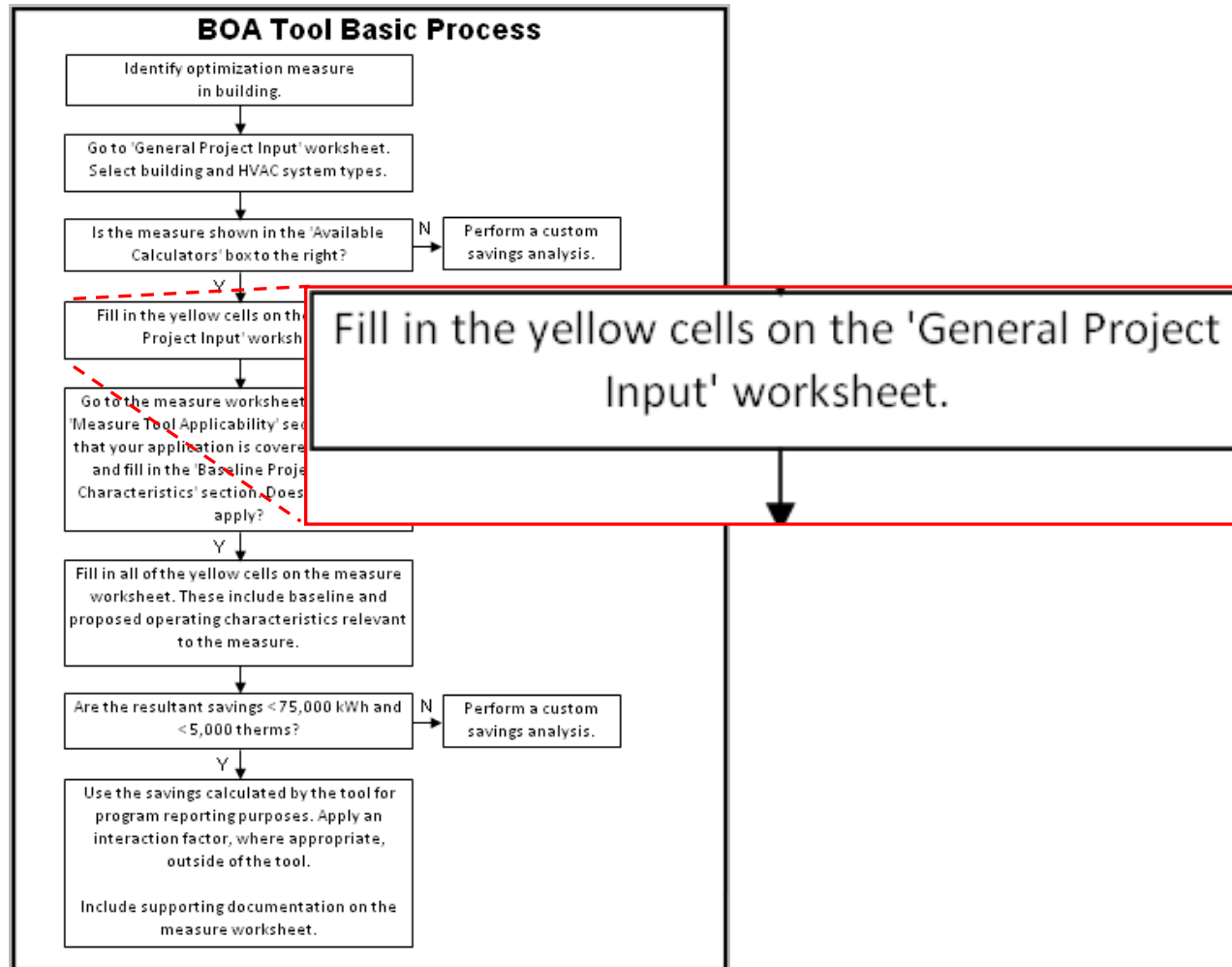
General Inputs	
Building Type	Education - University
Primary Ventilation System Type	VAV AHU / RTU w/ zone reheat
Primary Cooling System Type	Water-Cooled Chiller(s)
HVAC Heating System Type	Natural Gas Water Boiler

Available calculators based on selected building and system types:

SF Schedule
 Lighting Schedule
 Boiler Lockout - Not Applicable
 Economizer - Not Applicable
 Zone Temperature Deadband
 SAT Reset
 DSP Reduction - Not Applicable
 DSP Reset - Not Applicable
 SF VFD - Not Applicable
 CHWST Reset
 CWST Reset - Not Applicable
 CHW Pump VFD - Not Applicable



Second step: fill in remaining general project inputs

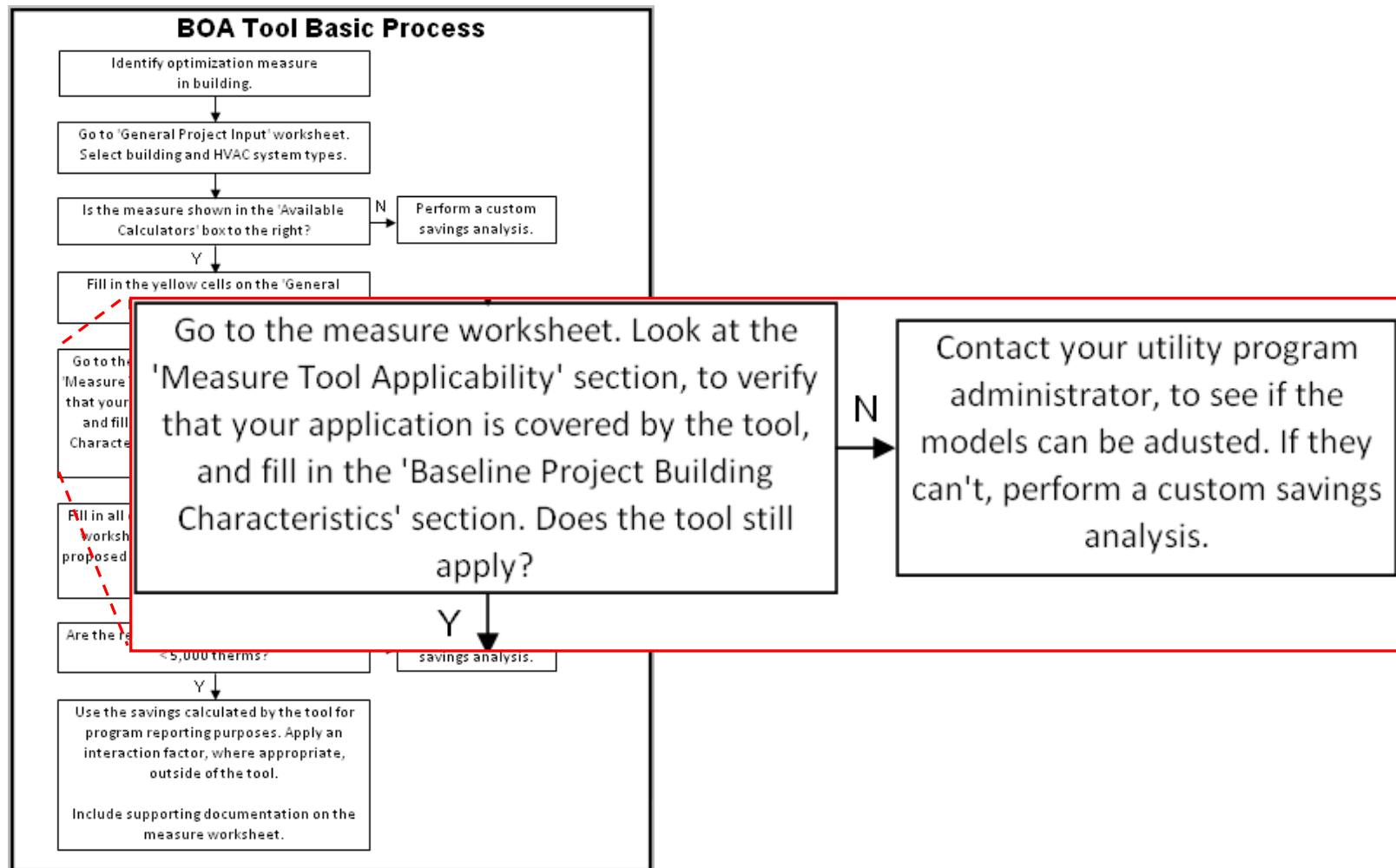


General Project Inputs

General Information & General Inputs	
General Project Information	
Facility Name	(facility name)
Facility Address	(facility address)
Utility Account Number	(utility account number)
Provider Information	
Name	(provider name)
Company	(provider company)
Address	(provider address)
Email	(provider email)
Phone number	(provider phone)
Date	(date)
General Inputs	
Building Type	Hospital
Primary Ventilation System Type	VAV AHU / RTU w/ zone reheat
Primary Cooling System Type	Water-Cooled Chiller(s)
HVAC Heating System Type	Natural Gas Water Boiler
Zip Code	94112 (CZ3) San Francisco
CA Climate Zone	3
Year Building Constructed	1985
Facility Gross Area (ft ²)	175,000
Baseline Building Energy Use	
Baseline Annual Electric Use (kWh)	2,352,000
Baseline Annual Gas Use (Therms)	18,500
Electric EUI (kWh/ft ²)	13.4
Gas EUI (therms/ft ²)	0.1
Total EUI (kBtu/ft ²)	56.4

- “General Project Input” worksheet
- Fill in yellow cells
- “Facility Area” is only used for EUI calcs, not for savings calcs

Third step: go to the applicable measure worksheet



Measure Discussion

Airside Economizer

Measure Discussion

The "Economizer" measure relates to either raising the dry bulb lockout temperature of an integrated airside economizer system, or restoring proper operation of the outside and return air dampers from a fixed position. Integrated airside economizer systems allow for 100% outside air when the outside air temperature is between the supply air temperature and the return air temperature, even when mechanical cooling is called for.

Applicable Baseline Conditions

- Economizer damper lockout temperature is 55F, 60F, or 65F.
- Dampers are stuck in a fixed position that is drawing in either 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, or 100% outside air.

Applicable Measures

- The economizer damper lockout temperature is raised to at least 70F.
- Proper modulating operation of the outside air and return air dampers is restored.

Applicable
baseline and
proposed
conditions for
each measure

Baseline Project Building Characteristics

- Fill in this section
 - More yellow cells

Baseline Project Building Characteristics	
VAV or CAV air handlers?	
Water-cooled or air-cooled chillers?	
CHWST reset?	
HWST reset?	
Fixed or variable CWST setpoints?	
<i>These inputs are for use in determining tool applicability, and do not impact the savings calculations. If baseline project building characteristics do not match tool applicability, contact your utility program administrator.</i>	

- For use in determining tool applicability
 - These inputs aren't used in the savings calcs

Baseline Project Building Characteristics

- Hover over white cells to learn about Tool applicability

Baseline Project Building Characteristics	
VAV or CAV air handlers?	VAV
Water-cooled or air-cooled chillers?	Tool applies to water-cooled chillers
CHWST reset?	
HWST reset?	
Fixed or variable CWST setpoints?	
These inputs are for use in determining tool applicability, and do not impact the savings calculations. If baseline project building characteristics do not match tool applicability, contact your utility program administrator.	

- If project characteristics don't match applicability, contact the program

Tool Applicability Discussion

- Tool applicability is also discussed in the “Measure Tool Applicability” section

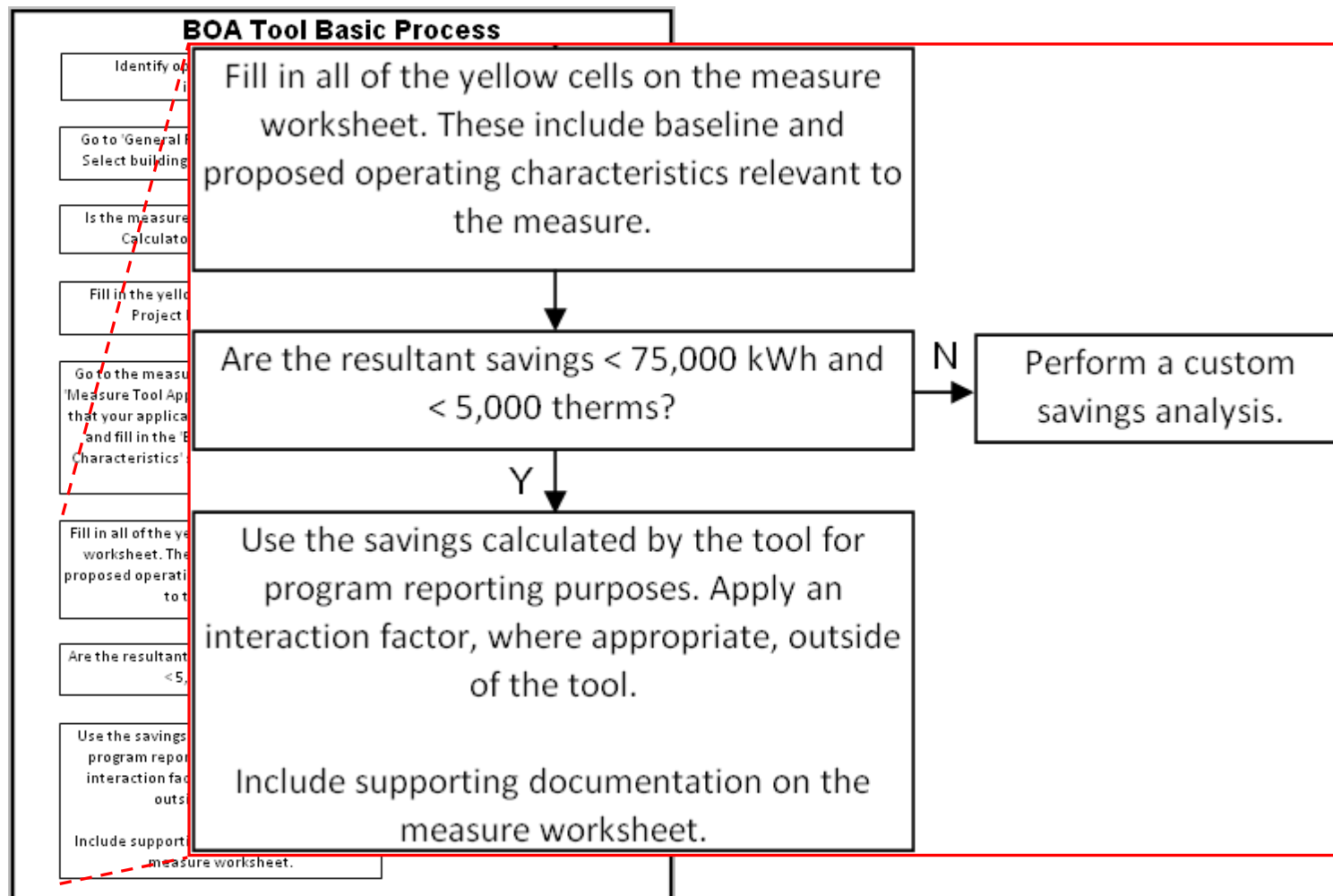
Measure Tool Applicability

The tool applies to VAV systems in Hospital, Office, and Retail building types:

- VAV air handlers with chilled water cooling coils and airside economizer sections serving the occupied spaces, with typical minimum ventilation rates.
- Natural gas-fired 80% efficient heating water boilers
- Chilled water systems with constant speed chillers and constant speed chilled water pumps. No chilled water supply temperature reset for buildings older than 1999, load-based reset for buildings built more recently than 2000.
- Heating water systems with no heating water supply temperature reset for buildings older than 1999, load-based reset for buildings built more recently than 2000.
- Water-cooled chillers. Cooling towers with either single speed, two speed, or VFD-controlled fans. Fixed condenser water temperature setpoints.

For Education and Hotel building types, contact your utility program administrator.

Fourth step: Calculate savings



Measure Worksheet

Inputs				
Building Type	Office			
CA Climate Zone	9			
Year Building Constructed	1985			
Baseline Lockout Temp or % Outside Air	60% fixed OA			
Air Handler Cooling Capacity (tons)	50			

Savings Outputs				
Annual Electric Savings	38,459	kWh/yr	1.6%	% of Annual Use
DEER Peak Electric Demand Savings	20.1	kW		
Annual Natural Gas Savings	33	Therms/yr	0.2%	% of Annual Use

- Put project-specific inputs in yellow cells
- Look to green cells for savings

Exercise #2

What are the savings for this scenario?

- Lighting scheduling measure
- 60,000 sf office building in San Francisco (zip code = 94111) constructed in 1986.
 - Baseline whole building usage = 900,000 kWh and 6,000 therms
- HVAC system = constant volume rooftop units (electric cooling / gas heating)
- Measure:
 - Reduce lighting schedule by 200 hours / year in open office area
 - Affected lighting power density = 1.2 W/sf
 - Affected lighting power = 36 kW

Exercise #2 Debrief

- Answer = 4,110 kWh/yr, -27 therms/yr

General Inputs	
Building Type	Office
Primary Ventilation System Type	Single zone CAV AHU / RTU
Primary Cooling System Type	Direct Expansion (DX)
HVAC Heating System Type	Gas Furnace
Zip Code	94111 (CZ3) San Francisco
CA Climate Zone	3
Year Building Constructed	1986
Facility Gross Area (ft ²)	60,000

Baseline Building Energy Use	
Baseline Annual Electric Use (kWh)	900,000
Baseline Annual Gas Use (Therms)	6,000

Baseline Project Building Characteristics	
Space type affected	Open office area
Connected lighting power density affected, W/sf	1.20
<i>These inputs are for use in determining tool applicability, and do not impact the savings calculations. If baseline project building characteristics do not match tool applicability, contact your utility program administrator.</i>	

Inputs	
Building Type	Office
CA Climate Zone	3
Year Building Constructed	1986
Number of Annual Lighting Operating Hours Reduced	200
Connected Lighting Power Affected, kW	36

Savings Outputs			
Annual Electric Savings	4,110 kWh/yr	0.5%	% of Annual Use
Annual Natural Gas Savings	-27 Therms/yr	-0.4%	% of Annual Use

Warnings and Errors: No warnings or errors exist for this measure

BOA Tool includes error messages

- If measure savings exceeds 5% of whole building usage

Savings Outputs				
Annual Electric Savings	62,748	kWh/yr	7.0%	% of Annual Use
Annual Natural Gas Savings	0	Therms/yr	0.0%	% of Annual Use
<i>Warnings and Errors:</i>				
WARNING: Electric percent savings exceeds typical values. Please review inputs.				

BOA Tool includes error messages

- If measure savings exceeds 75,000 kWh or 5,000 therms

Savings Outputs				
Annual Electric Savings	125,495	kWh/yr	13.9%	% of Annual Use
Annual Natural Gas Savings	0	Therms/yr	0.0%	% of Annual Use
<i>Warnings and Errors:</i>				
ERROR: Savings exceeds typ. max. allowable values for use of tool: 75000 kWh & 5000 therms. Custom analysis is required.				

After Calculating Savings

- If savings is greater than 75,000 kWh or 5,000 therms, perform a custom calc
- Apply an interaction factor as appropriate
 - For measures that may interact with each other. E.g., airside economizer and CHWST reset.

A note about measure-to-measure interactions

- Measures with green tabs are schedule- and load-based measures
 - Do these first



- Adjust baseline conditions for orange tab measures accordingly
 - E.g., SF Schedule can impact SAT Reset



Include Supporting Documentation

- Trend data, screenshots, photos, etc.
- Important to:
 - Demonstrate the problem (baseline data)
 - Demonstrate the fix (post-implementation verification data)
 - Supporting documentation can be input directly into the BOA Tool
- Can add / resize rows and columns in Supporting Documentation section

Multiple Scenarios

- The BOA Tool can be used for multiple measure scenarios
 - Multiple equipment with the same measure
 - Copy and rename the worksheets as needed



- Multiple building types
 - Save multiple versions of the BOA Tool

Exercise #3

What are the savings for this scenario?

- Duct static pressure reduction measure.
- 130,000 sf retail building (3-story) in Los Angeles (zip code = 90210) constructed in 2001.
 - Baseline whole building usage = 2,340,000 kWh and 6,500 therms
- HVAC system = VFD-controlled VAV AHUs operating 5,000 hrs / year. Water-cooled chillers and gas-fired hot water boilers.
- Measure:
 - For AH-1 (40 HP), reduce DSP setpoint from 2" to 1.6".
 - For AH-2 (20 HP), reduce DSP setpoint from 2" to 1.5".

Exercise #3 Debrief

- Answer = 8,276 kWh/yr, 2.3 kW

General Inputs	
Building Type	Retail - 3-Story
Primary Ventilation System Type	VAV AHU / RTU w/ zone reheat
Primary Cooling System Type	Water-Cooled Chiller(s)
HVAC Heating System Type	Natural Gas Water Boiler
Zip Code	90210 (CZ9) Los Angeles
CA Climate Zone	9
Year Building Constructed	2001
Facility Gross Area (ft ²)	130,000
Baseline Building Energy Use	
Baseline Annual Electric Use (kWh)	2,340,000
Baseline Annual Gas Use (Therms)	6,500

Baseline Project Building Characteristics	
VAV or CAV air handlers?	VAV
Supply fan motor control	VFD
Actual fan annual operating hours	5,000
These inputs are for use in determining tool applicability, and do not impact the savings calculations. If baseline project building characteristics do not match tool applicability, contact your utility program administrator.	

Inputs	
Building Type	Retail - 3-Story
CA Climate Zone	9
Year Building Constructed	2001
Affected Fan Motor HP	40
Proposed Setpoint Reduction	0.4

Savings Outputs		
Annual Electric Savings	5,073 kWh/yr	0.2% % of Annual Use
DEER Peak Electric Demand Savings	1.4 kW	
Warnings and Errors: No warnings or errors exist for this measure		

Baseline Project Building Characteristics	
VAV or CAV air handlers?	VAV
Supply fan motor control	VFD
Actual fan annual operating hours	5,000
These inputs are for use in determining tool applicability, and do not impact the savings calculations. If baseline project building characteristics do not match tool applicability, contact your utility program administrator.	

Inputs	
Building Type	Retail - 3-Story
CA Climate Zone	9
Year Building Constructed	2001
Affected Fan Motor HP	20
Proposed Setpoint Reduction	0.5

Savings Outputs		
Annual Electric Savings	3,203 kWh/yr	0.1% % of Annual Use
DEER Peak Electric Demand Savings	0.9 kW	
Warnings and Errors: No warnings or errors exist for this measure		

5,073 kWh/yr	+	3,203 kWh/yr
1.4 kW		0.9 kW

Fast Savings Analysis

- For your next RCx project, take the BOA Tool with you onsite
 - Determine Tool applicability
 - Determine necessary inputs
 - Calculate rough savings



Outside air damper
“stuck” at 100% open

Using the BOA Tool: Key Takeaways

- The flowchart is your friend
- Resist the urge to go straight to the measure worksheets
 - Start at the “Tool Applicability” and “General Project Input” worksheets
- Ask for help
 - boatool@peci.org
 - Your utility program administrator

Integration of the BOA Tool with the RCx Programs

- Use the BOA Tool wherever possible & applicable
- Can use BOA Tool both pre- and post-measure implementation
- Report savings from the BOA Tool in your program's RCx measure log (e.g., *Findings Workbook*)
- Expect that BOA Tool baseline assumptions, inputs, and savings will be reviewed by the utility
- Follow all applicable and/or forthcoming RCx program guidelines regarding the BOA Tool
- Contact your utility program administrator with any questions

Program Administrators

- SCE RCx Program: Mugi Lukito, Project Manager (Mugimin.Lukito@sce.com)
- SoCal Gas: Glenda Towns, RCx Program Manager (gtowns@semprautilities.com); Raad Bashar, Engineer (RBashar@semprautilities.com)
- SMUD: Mark Jagodzinski, Senior Product Service Coordinator (mjagodz@smud.org)
- PG&E RCx Program: Tia Hansen, Program Manager, Newcomb Anderson McCormick (Tia_Hansen@newcomb.cc)
- San Diego RCx Program: Michelle Lichtenfels, Program Manager, PECI (mlichtenfels@peci.org)

BOA Tool Resources

Resources:

- BOA Tool (Excel)
- CALMAC report on SCE work: <http://bit.ly/a3Gj48>
- Final Report on PG&E work (coming soon)
- Training session presentation (PDF)
- Training session recording
- BOA Tool technical support: boatool@peci.org

Tool & resources available on CCC website and program websites by September 30, 2010 – stay tuned!

- CCC: www.cacx.org/resources/providers.html
- SCE: www.sce-rcx.com/rcx_resources.html
- San Diego RCx Program: www.sandiegorcx.com/resources.html
- PG&E: TBD

BOA Tool Technical Support

boatool@peci.org

**24 hour response time on questions received
during the work week**

Thank you!