Cost and Energy Savings
- Energy - 10 to 15 Percent over non-commissioned buildings
- Reduced change orders

Customer / Occupant Satisfaction
- Improved comfort and indoor air quality

Smoothe Construction Process
- Avoided construction problems, reduced callbacks

Meet LEED certification requirements

And, One More Motivation...
“Get onboard…the train has left and we are moving forward”
Executive Order S-20-04

Signed December 14, 2004
Green Building Action Plan

- Design, construct and operate all State facilities as “LEED Silver” or higher
  - New & renovated buildings > 10,000 sq. ft.

“Building projects less than 10,000 sq. ft. shall use the same design standard, but certification is not required.”
State Small Building Types

Forest Fire Stations
- 228 CDF fire stations in 36 counties protecting 31 million acres
- 575 local gov’t stations operated by CDF
- 39 conservation camps
- Storage facilities for fire trucks, bulldozers, air tankers & air tactical planes, helicopters
- Barracks, shops, warehouses, admin facilities, misc. structures

Department of Motor Vehicles
- 170 field offices throughout CA
- Also driver safety offices, commercial drive test centers, telephone service centers

California Highway Patrol
- Over 180 offices throughout CA
DGS Project Teams

- Project Directors
- Architects
- Mechanical & Electrical Design Engineers
- Building Inspectors
- Building Inspection Specialists (Mechanical & Electrical)
- General Contractor & Sub-contractors
Leadership in Energy and Environmental Design (LEED)

- Green building rating system
- Administered by U.S. Green Building Council (www.usgbc.org)

Building Criteria for:

- Sustainable Sites
- Water Efficiency
- Energy & Atmosphere
- Materials & Resources
- Indoor Environmental Quality
- Innovation in Design

Point System with Levels of Certification

- Certified, Silver, Gold, Platinum

EA Prerequisite 1: Fundamental Building Commissioning
EA Credit 3: Enhanced Commissioning
In-House Commissioning (Cx) Toolkit

- Executive Summary
- Roadmap/Instructions
- Tools:
  - Owner’s Project Requirements
  - LEED Cx Requirements
  - Basis of Design
  - Cx Plan
  - Contract Requirements
  - Functional Performance Test Forms
  - Cx Summary Report
- Other Resources

www.green.ca.gov/CxToolkit
One-page Summary of Cx Toolkit

- Definition of Cx
- Executive Order S-20-04
- LEED Cx Requirements
- Purpose & Content of Toolkit
- Benefits of Cx Integration
Instructions on Use of Toolkit

Integrate Cx as Early as Possible
- Portions can be integrated in budget pkg.

Identify Cx Provider
- Design Phase – Design engineer
- Construction Phase – M/E Inspection Specialists

Develop Cx Plan

Implement Activities in Cx Plan
DGS Commissioning Toolkit

- Owner’s Project Requirements
- Basis of Design
- Commissioning Plan
- Commissioning Specifications
- A&E Commissioning Scope of Work
- Functional Performance Test Forms
- Commissioning Summary Report
Owner’s Project Requirements (OPR)

- Owner and User Requirements
- Environmental and Sustainability Goals
- Energy Efficiency Goals
- Indoor Environmental Quality Requirements
- Equipment and Systems Expectations
- Building Occupant and O&M Personnel Expectations
Basis of Design (BOD)

- **HVAC System**
  - Narrative Description of System
  - Reasons for System Selection
  - Load Calculations
  - Sequence of Operations

- **Indoor Lighting System**
  - Narrative Description of System
  - Reasons for System Selection
  - Lighting Design Criteria
  - Lighting Power Design Targets

- **Water Heating System**
  - Narrative Description of System
  - Reasons for System Selection
  - Water Heating Load Calculations
Commissioning Plan

- General Project Information
- Commissioning Goals
- Systems to be Commissioned
- Commissioning Team Information
- Commissioning Process – Activities, Schedule and Responsibilities
## Commissioning Plan Activities

<table>
<thead>
<tr>
<th>Commissioning Activity</th>
<th>Timing (Project Phase)</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner’s project requirements (OPR)</td>
<td>Concept / Budget</td>
<td>Project team, led by Project Director, with CxA review</td>
</tr>
<tr>
<td>Cx Plan</td>
<td>Concept / Budget or PP</td>
<td>CxA</td>
</tr>
<tr>
<td>Basis of Design (BOD)</td>
<td>PP or WD</td>
<td>Design Team, with CxA review</td>
</tr>
<tr>
<td>Cx Specifications</td>
<td>WD</td>
<td>Design Team, with CxA review</td>
</tr>
<tr>
<td>Cx Kick-off Meeting</td>
<td>Const.</td>
<td>Lead by CxA, attended by Contractor</td>
</tr>
<tr>
<td>Develop pre-functional checklists</td>
<td>WD or Const.</td>
<td>CxA (or Design Team)</td>
</tr>
</tbody>
</table>
### Commissioning Plan Activities (cont.)

<table>
<thead>
<tr>
<th>Commissioning Activity</th>
<th>Timing (Project Phase)</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop functional test procedures</td>
<td>WD or Const.</td>
<td>CxA (or Design Team)</td>
</tr>
<tr>
<td>Complete prefunctional checklists</td>
<td>Const.</td>
<td>Contractor, with CxA (or Inspector) review</td>
</tr>
<tr>
<td>Perform functional performance testing</td>
<td>Const.</td>
<td>Contractor, with CxA (or Inspector) guidance, witness and approval</td>
</tr>
<tr>
<td>Commissioning acceptance</td>
<td>Const.</td>
<td>CxA</td>
</tr>
<tr>
<td>Cx Summary Report</td>
<td>Const.</td>
<td>CxA</td>
</tr>
</tbody>
</table>
Commissioning Specifications

- Describes contractor participation requirements

- Division 1 Section
  - 01810 General Commissioning Requirements

- References in relevant mechanical and electrical sections
A&E Scope of Work

- Describes additional scope for commissioning role of design team
- Currently under development
Functional Performance Test (FPT) Forms

**HVAC**
- Packaged rooftop AC units
- Split system AC units

**Lighting**
- Occupancy sensor controls

**Water Heating**
- Storage water heater
- Point-of-use water heater
# Prefunctional Checklist

Record values for current setpoints, control parameters, limits, delays, lockouts, etc. and note any deviation from design.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Per Design</th>
<th>Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power to unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power disconnects installed and labeled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermostat is wired to the HVAC system correctly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermostat meets deadband control requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space temperature sensor calibrated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupied, unoccupied, and holiday schedules programmed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-occupancy purge has been programmed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set up and set back setpoints programmed as required</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermostat located within the zone that the HVAC unit serves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unoccupied avg. zone set points (e.g. 85°F setup/60°F setback)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schedule override</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensate drain connected</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ sensor location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ sensor calibrated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return air damper moves through full range</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor air damper moves through full range</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No excessive damper linkage stop.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permanent label attached.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit secure and level.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance access ok.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test, adjust and balance complete with deficiencies corrected.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor air economizer switchover type and setting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Casing condition ok.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Operating Schedule - Record time-of-day and setpoints and note any deviation from DESIGN

<table>
<thead>
<tr>
<th>DAY OF THE WEEK</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
<th>Override available?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design:</td>
<td>7AM-6PM</td>
<td>7AM-6PM</td>
<td>7AM-6PM</td>
<td>7AM-6PM</td>
<td>override</td>
<td>override</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>
### Simulation Mode/Test

<table>
<thead>
<tr>
<th>Simulation Mode/Test</th>
<th>Desired System Response (check box if observed)</th>
<th>Other Observed System Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Heating during occupied condition</td>
<td>Supply fan operates continually.</td>
<td>Gas-fired furnace, heat pump, or electric heater stages on.</td>
</tr>
<tr>
<td></td>
<td>No cooling is provided by the unit.</td>
<td>Outside air damper is open to minimum position.</td>
</tr>
<tr>
<td></td>
<td>Outside air damper is open to minimum position.</td>
<td></td>
</tr>
<tr>
<td>2. No load during occupied condition</td>
<td>Supply fan operates continually.</td>
<td>Gas-fired furnace, heat pump, or electric heater stages on.</td>
</tr>
<tr>
<td></td>
<td>Neither heating or cooling is provided by the unit.</td>
<td>Outside air damper is open to minimum position.</td>
</tr>
<tr>
<td></td>
<td>Outside air damper is open to minimum position.</td>
<td></td>
</tr>
<tr>
<td>3. Heating during unoccupied condition</td>
<td>Supply fan operates continually.</td>
<td>Gas-fired furnace, heat pump, or electric heater stages on.</td>
</tr>
<tr>
<td></td>
<td>No cooling is provided by the unit.</td>
<td>Outside air damper is open to minimum position.</td>
</tr>
<tr>
<td>4. No load during unoccupied condition</td>
<td>Supply fan operates continually.</td>
<td>Gas-fired furnace, heat pump, or electric heater stages on.</td>
</tr>
<tr>
<td></td>
<td>No heating or cooling is provided by the unit.</td>
<td>Outside air damper is open to minimum position.</td>
</tr>
<tr>
<td></td>
<td>Outside air damper is open to minimum position.</td>
<td></td>
</tr>
<tr>
<td>5. Cooling during occupied condition</td>
<td>Supply fan operates continually.</td>
<td>Gas-fired furnace, heat pump, or electric heater stages on.</td>
</tr>
<tr>
<td></td>
<td>No heating provided.</td>
<td>Compressor turns on and provides cooling.</td>
</tr>
<tr>
<td></td>
<td>Outside air damper is open to minimum position.</td>
<td></td>
</tr>
<tr>
<td>6. Manual Override (if system has this capability)</td>
<td>Supply fan operates continually.</td>
<td>No heating provided.</td>
</tr>
<tr>
<td></td>
<td>Outside air damper is open to minimum position.</td>
<td>Compressor turns on and provides cooling.</td>
</tr>
<tr>
<td></td>
<td>Outside air damper is open to minimum position.</td>
<td></td>
</tr>
<tr>
<td>7. Cooling during unoccupied condition</td>
<td>Supply fan operates continually.</td>
<td>Gas-fired furnace, heat pump, or electric heater stages on.</td>
</tr>
<tr>
<td></td>
<td>No heating provided.</td>
<td>Compressor turns on and provides cooling.</td>
</tr>
<tr>
<td></td>
<td>Outside air damper is open to minimum position.</td>
<td></td>
</tr>
<tr>
<td>8. Economizer operation (if unit equipped with economizer)</td>
<td>Supply fan operates continually.</td>
<td>Gas-fired furnace, heat pump, or electric heater stages on.</td>
</tr>
<tr>
<td></td>
<td>No heating provided.</td>
<td>Compressor turns on and provides cooling.</td>
</tr>
<tr>
<td></td>
<td>Outside air damper is open to minimum position.</td>
<td></td>
</tr>
</tbody>
</table>

### FPT – Packaged AC Unit (cont.)

**Simulation Mode/Test**

1. ** Heating during occupied condition **

   - Set control system or programmable thermostat to occupied mode (e.g., adjust clock time to normal working hours). Adjust thermostat to 5 deg higher than current room temperature.
   - Supply fan operates continually.
   - Gas-fired furnace, heat pump, or electric heater stages on.
   - No cooling is provided by the unit.
   - Outside air damper is open to minimum position.

2. **No load during occupied condition**

   - Leave system in occupied mode.
   - Adjust thermostat to equal current room temperature.
   - Supply fan operates continually.
   - Gas-fired furnace, heat pump, or electric heater stages on.
   - No cooling is provided by the unit.
   - Outside air damper is open to minimum position.

3. **Heating during unoccupied condition**

   - Set control system or programmable thermostat to occupied mode (e.g., adjust clock to after-hours time). Adjust thermostat to 5 deg higher than current room temperature.
   - Supply fan cycles on.
   - Gas-fired furnace, heat pump, or electric heater stages on.
   - No cooling is provided by the unit.
   - Outside air damper is open to minimum position.

4. **No load during unoccupied condition**

   - Leave system in occupied mode.
   - Adjust thermostat to equal current room temperature.
   - Supply fan cycles on.
   - Gas-fired furnace, heat pump, or electric heater stages on.
   - No cooling is provided by the unit.
   - Outside air damper is open to minimum position.

5. **Cooling during occupied condition**

   - Return control system or programmable thermostat to occupied mode (e.g., adjust clock to after-hours time). Adjust thermostat to 5 deg lower than current room temperature. To ensure that economizer damper does not turn off, either warm economizer sensor or if unit has adjustable inside economizer sensor, adjust sensor down to turn off economization.
   - Supply fan operates continually.
   - No heating provided.
   - Compressor turns on and provides cooling.
   - Outside air damper is open to minimum position.

6. **Economizer operation (if unit equipped with economizer)**

   - Leave system in occupied mode.
   - Adjust thermostat to 5 deg lower than current room temperature. If outdoor air temperature is lower than return air temperature, verify that economizer damper is open for 100% outdoor air. Otherwise, use cold spray on outdoor air sensor to simulate condition. Then remove cold spray and verify that economizer damper returns to minimum air position or warm the outside air sensor to simulate condition.
   - Supply fan operates continually.
   - No heating provided.
   - Outside air dampers open to 100%.
   - Outside air damper is open to minimum position.
   - Outside air damper returns to minimum air position.

7. **Cooling during unoccupied condition**

   - Return control system or programmable thermostat to occupied mode (e.g., adjust clock to after-hours time). Adjust thermostat to 5 deg lower than current room temperature.
   - Supply fan operates continually.
   - No heating provided.
   - Outside air dampers open to 100%.
   - Outside air damper is open to minimum position.

8. **Manual Override (if system has this capability)**

   - Leave system in occupied mode.
   - Adjust thermostat to equal current room temperature.
   - Supply fan operates continually.
   - Gas-fired furnace, heat pump, or electric heater stages on.
   - No cooling is provided by the unit.
   - Outside air damper is open to minimum position.
Commissioning Summary Report

- General Project Information
- Commissioning Team Information
- Executive Summary
  - Commissioning Process Summary
  - Outstanding Issues
  - Observations and Conclusions
- History of Deficiencies
Conclusion / Other Resources

Start Now – Begin with Owner’s Project Requirements

Online Toolkit – [www.green.ca.gov/CxToolkit](http://www.green.ca.gov/CxToolkit)

Other Useful websites/documents:

- California Commissioning Collaborative: [www.cacx.org](http://www.cacx.org)
- Portland Energy Conservation, Inc. (PECI): [www.peci.org](http://www.peci.org)
- Building Commissioning Association (BCxA): [www.bcxa.org](http://www.bcxa.org)
- LEED-NC v2.2 Reference Guide
  - Prerequisite 1 – pp 149-161;
  - Credit 3 – pp 205-210
For More Information

Dan Burgoyne
Sustainability Manager
State of California, Department of General Services
Executive Office, Office of Sustainability
707 Third Street, 8th Floor, West Sacramento, CA 95630

(916) 376-5010 - office
Daniel.Burgoyne@dgs.ca.gov

www.green.ca.gov/CxToolkit