Energy Efficiency Concepts

1. Energy Efficiency and Conservation
2. Comfort and perception
3. Proactive Design
4. Performance-based Design Goals
5. Integrated Systems Design Process
6. Long-term cost-effectiveness
## Energy Savings Terms

### Conservation
- Behavioral approach
- Immediate results
- Short-term effects
- Occupants may be uncomfortable
- Reduces waste

### Energy Efficiency
- Technological approach
- Smaller results
- Long-term effects
- Occupants comfortable

### Site Generation
- Technological approach
- Supplying energy, not reducing the need for it
- Eliminates transmission losses

“Demand” = Time at which you use conservation, efficiency or generation
Comfort and Perception

- 10% of all occupants are always dissatisfied
- **Human thermal comfort** is determined
  - ≈ 30% from air temperature
  - ≈ 50% from radiant (surface) temperature
- Using energy to control surface temperatures has nearly twice the impact on human comfort

  - \textit{Low-E glass} reflects body heat in, sunlight out
  - \textit{Radiant heating and cooling} warms or cools the body first and eliminates draft, dust, and noise
Performance-based Analysis

- Building energy simulation software makes performance-based whole building analysis possible:
  - Comparison of combinations of energy efficiency measures
    - Comparison of proposed design against a baseline (e.g. Title 24)
    - Evaluation of building performance relative to a threshold (e.g. incentive programs)
Building Energy Simulation

- Buildings are modeled using weather data specific to one of 16 CA climate zones
- Calculations for compliance (Title 24)
- Calculations for energy efficiency design
- Same software can be used for both
- Each specific energy measure can be modeled
- Interactions between measures can be modeled
Performance-Based Design

- Evaluation of combined measures allows for substitutions of individual measures and then re-evaluation
- Energy performance feedback loop is an essential tool in the energy efficient design process
- Enables evaluation of most cost-effective solutions
- Skilled energy consultant becomes key design team specialist
Integrated Systems Design

- Individual building components are considered as part of integrated and interactive systems:
  - The building envelope design impacts HVAC sizing
  - Skylights with daylighting controls reduce electric lighting loads
  - Electric lighting increases cooling requirements
  - Waste heat from one system can power another

- Separate building loads are aggregated into a single interactive whole building model
Proactive Design with Performance-based Design

- Measures performance
  -> in energy (kBTU/sf/yr) savings/square foot/year
  -> and by % improvement over threshold

- Allows trade-off between measures

- Can result in more cost-effective solutions

- But, watch out for “gaming”…
  -> “What is the least I can do to meet compliance?”
Maximize Cost-Effectiveness with Proactive Design

- Involve an energy consultant as early as possible in the design process
- Optimize building orientation, window areas and any other potential design restrictions BEFORE they are locked in by the entitlement process
- Think *high performance*, versus adapting to limitations set by others in the design process
- Early team collaboration results in the most cost-effective solutions
Long-term cost-effectiveness

- First cost is important but look at life-cycle cost
- Does energy efficiency add value to a building?
- If energy costs continue to sharply rise, where will people want to live?
- Owners: can you afford not to build an energy efficient building?
- Designers: can you afford not to become expert in the design of energy efficient buildings?
Utilize Parametric Analyses

- **Parametric analysis**
  - Design optimization method
  - Take one variable type (e.g. window solar heat gain properties) and test with a series of values
  - Results show relationships between elements

- **Test sensitivities to**
  - Building orientation
  - Window area and orientation distribution
  - Hot water heating equipment efficiency, distribution system and controls…etc
Title 24 Basics

- Mandatory Measures
  - lighting efficiency
  - shell insulation minimums
  - equipment efficiency minimums
  - appliance standards

- Prescriptive Packages
  - establishes Performance baseline
  - Climate Zone dependant

- Performance Calculation
The Energy Performance Approach for a building shows how much energy the **proposed design** is estimated to use, **compared to** the estimated energy use of the **standard design**. The difference is expressed as a percentage of the standard design.
Performance Approach

- T-24 Performance Approach compares standard prescriptive design to proposed design
  - **Envelope:**
    - Orientation, Insulation, Windows, Assemblies
  - **HVAC:**
    - Heating and Cooling equipment and distribution
  - **DHW:**
    - Central and individual water heating equipment & distribution

- Software programs are used to demonstrate at least 15% > T-24 and positive electric energy savings
  - EnergyPro (Low rise and High rise)
  - MICROPAS (Low rise only)
At least 15% > 2005 code (MICROPAS)

<table>
<thead>
<tr>
<th>Energy Use</th>
<th>Standard Design</th>
<th>Proposed Design</th>
<th>Compliance Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(kTDV/sf-yr)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space Heating.......</td>
<td>4.38</td>
<td>5.12</td>
<td>-0.74</td>
</tr>
<tr>
<td>Space Cooling.......</td>
<td>2.08</td>
<td>2.62</td>
<td>-0.54</td>
</tr>
<tr>
<td>Water Heating.......</td>
<td>23.11</td>
<td>16.61</td>
<td>6.50</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>29.57</strong></td>
<td><strong>24.35</strong></td>
<td><strong>5.22</strong></td>
</tr>
</tbody>
</table>

*** Building complies with Computer Performance ***
*** HERS Verification Required for Compliance ***

- Compliance Margin / Standard Design: 5.22/29.57 = 17.65%
- Negative Electric Energy: Does not comply
## Certificate Of Compliance : Residential (Part 1 of 4)  

**Project Title**  
SANTA ANNA STREET  SANTA PAULA  

**Documentation Author**  
Heschong Mahone Group  
(916) 962-7001  

**EnergyPro**  
9  

<table>
<thead>
<tr>
<th>TDV Energy Use (kBtu/sf-yr)</th>
<th>Standard Design</th>
<th>Proposed Design</th>
<th>Compliance Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Heating</td>
<td>3.76</td>
<td>4.92</td>
<td>-1.16</td>
</tr>
<tr>
<td>Space Cooling</td>
<td>7.38</td>
<td>8.56</td>
<td>-1.18</td>
</tr>
<tr>
<td>Fans</td>
<td>1.43</td>
<td>1.71</td>
<td>-0.28</td>
</tr>
<tr>
<td>Domestic Hot Water</td>
<td>20.51</td>
<td>12.32</td>
<td>8.19</td>
</tr>
<tr>
<td>Pumps</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>33.08</strong></td>
<td><strong>27.52</strong></td>
<td><strong>5.57</strong></td>
</tr>
</tbody>
</table>

Percent better than Standard: **16.8%**

**BUILDING COMPLIES - HERS VERIFICATION REQUIRED**

- **Building Type:**  
  - [x] Multi Family
  - [ ] Single Family
  - [ ] Addition
  - [ ] Existing + Add/Alt

- **Total Conditioned Floor Area:**  
  - 946 ft²

- **Existing Floor Area:**  
  - n/a ft²

7/31/2008  
Multifamily Comprehensive Training - LACDC
High-rise Multifamily and T-24

High-rise buildings are modeled differently than Low-rise

- Envelope and HVAC = Non-residential stds
- Lighting and Domestic Hot Water (DHW) = Residential stds
- High-rise and Low-rise use different calculation engines
  - High-rise calculations de-emphasize envelope measures
  - Assume internal heat gain as in typical non-res buildings
- For buildings w/ central DHW system:
  - The water heaters/boilers need to meet efficiency requirements of sections 111 and 113, and
  - Automatic controls that shut-off the circulating pump when there is no need for hot water are required
### PERFORMANCE CERTIFICATE OF COMPLIANCE

**PROJECT NAME**
VILLA SIENA BUILDING-10  
**DATE**

<table>
<thead>
<tr>
<th>ENERGY COMPONENT</th>
<th>Standard Design</th>
<th>Proposed Design</th>
<th>Compliance Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Heating</td>
<td>2.02</td>
<td>1.84</td>
<td>0.18</td>
</tr>
<tr>
<td>Space Cooling</td>
<td>41.51</td>
<td>31.07</td>
<td>10.45</td>
</tr>
<tr>
<td>Indoor Fans</td>
<td>5.04</td>
<td>4.46</td>
<td>0.58</td>
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<tr>
<td>Heat Rejection</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Pumps &amp; Misc.</td>
<td>0.00</td>
<td>0.86</td>
<td>-0.86</td>
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<tr>
<td>Domestic Hot Water</td>
<td>15.05</td>
<td>11.67</td>
<td>3.38</td>
</tr>
<tr>
<td>Lighting</td>
<td>28.44</td>
<td>28.44</td>
<td>0.00</td>
</tr>
<tr>
<td>Receptacle</td>
<td>28.44</td>
<td>28.44</td>
<td>0.00</td>
</tr>
<tr>
<td>Process</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**TOTALS:**
Standard: 120.50  
Proposed: 106.77  
Compliance Margin: 13.73

Percent better than Standard: **only 11.4%**

### GENERAL INFORMATION

7/31/2008  
Multifamily Comprehensive Training - LACDC
## High-Rise Title 24 PERF-1 Program Compliance

### PERFORMANCE CERTIFICATE OF COMPLIANCE

**Part 2 of 3**

**PERF-1**

<table>
<thead>
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<th>DATE</th>
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</thead>
<tbody>
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<td>3/23/2006</td>
</tr>
</tbody>
</table>

### ANNUAL PRIMARY (kBtu/sqft-yr)

<table>
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<tr>
<th>ENERGY COMPONENT</th>
<th>Standard Design</th>
<th>Proposed Design</th>
<th>Compliance Margin</th>
</tr>
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<tbody>
<tr>
<td>Space Heating</td>
<td>2.02</td>
<td>1.84</td>
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<tr>
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</tr>
<tr>
<td>Indoor Fans</td>
<td>5.04</td>
<td>4.46</td>
<td>0.58</td>
</tr>
<tr>
<td>Heat Rejection</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>Pumps &amp; Misc.</td>
<td>0.00</td>
<td>0.86</td>
<td>-0.86</td>
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<tr>
<td>Domestic Hot Water</td>
<td>15.05</td>
<td>11.67</td>
<td>3.38</td>
</tr>
<tr>
<td>Lighting</td>
<td>28.44</td>
<td>28.44</td>
<td>0.00</td>
</tr>
<tr>
<td>Receptacle</td>
<td>28.44</td>
<td>28.44</td>
<td>0.00</td>
</tr>
<tr>
<td>Process</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**TOTALS:** 106.77

Percent better than Standard: 11.4% (11.4% excluding process)

**BUILDING COMPLIES**

\[ \frac{13.73}{63.62} = 21.58\% \]
Prescriptive Envelope Requirements

Low rise Package D - Table 151-C

LR see appendix B in 2005 standards

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
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</thead>
<tbody>
<tr>
<td><strong>Building Envelope</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>Insulation minimums</td>
<td>R38</td>
<td>R30</td>
<td>R30</td>
<td>R30</td>
<td>R30</td>
<td>R30</td>
<td>R30</td>
<td>R30</td>
<td>R30</td>
<td>R38</td>
<td>R38</td>
<td>R38</td>
<td>R38</td>
<td>R38</td>
<td>R38</td>
<td>R38</td>
</tr>
<tr>
<td>Wood-frame walls</td>
<td>(R4.76)</td>
<td>(R2.44)</td>
<td>(R2.44)</td>
<td>(R2.44)</td>
<td>(R2.44)</td>
<td>(R2.44)</td>
<td>(R2.44)</td>
<td>(R2.44)</td>
<td>(R4.76)</td>
<td>(R4.76)</td>
<td>(R4.76)</td>
<td>(R4.76)</td>
<td>(R4.76)</td>
<td>(R4.76)</td>
<td>(R4.76)</td>
<td>(R4.76)</td>
</tr>
<tr>
<td>&quot;Heavy mass&quot; walls</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>&quot;Light mass&quot; walls</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
</tr>
<tr>
<td>Below-grade walls</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
</tr>
<tr>
<td>Slab floor perimeter</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Concrete raised floors</td>
<td>R8</td>
<td>R8</td>
<td>R8</td>
<td>R8</td>
<td>R8</td>
<td>R4</td>
<td>R8</td>
<td>R8</td>
<td>R8</td>
<td>R8</td>
<td>R8</td>
<td>R8</td>
<td>R8</td>
<td>R8</td>
<td>R8</td>
<td>R8</td>
</tr>
<tr>
<td>Radiant Barrier</td>
<td>NR</td>
<td>REQ</td>
<td>NR</td>
<td>REQ</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
</tbody>
</table>

**Fenestration**

| Maximum U-factor | 0.57 | 0.57 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 | 0.55 |
| Maximum Solar Heat Gain Coefficient (SHGC) | NR | 0.40 | NR | 0.40 | NR | 0.40 | 0.40 | 0.40 | NR | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | NR |
| Maximum total area | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% |
| Maximum West facing area | NR | 5% | NR | 5% | NR | 5% | NR | 5% | NR | 5% | NR | 5% | NR | 5% | NR | 5% |
# Prescriptive Envelope Requirements

**TABLE 143.B PRESCRIPTIVE ENVELOPE CRITERIA FOR HIGH-RISE RESIDENTIAL BUILDINGS AND GUEST ROOMS OF HOTEL/MOTEL BUILDINGS**

<table>
<thead>
<tr>
<th>CLIMATE ZONES</th>
<th>1, 16</th>
<th>2-5</th>
<th>6-9</th>
<th>11-13</th>
<th>14, 15</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Roof/ Ceiling</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U-factor</td>
<td>0.016</td>
<td>0.011</td>
<td>0.015</td>
<td>0.036</td>
<td>0.036</td>
</tr>
<tr>
<td>R-value</td>
<td>30</td>
<td>19</td>
<td>19</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td><strong>Wall</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-value</td>
<td>19</td>
<td>11</td>
<td>11</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>U-factor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood frame</td>
<td>0.074</td>
<td>0.110</td>
<td>0.110</td>
<td>0.102</td>
<td>0.102</td>
</tr>
<tr>
<td>Metal frame</td>
<td>0.113</td>
<td>0.224</td>
<td>0.224</td>
<td>0.217</td>
<td>0.217</td>
</tr>
<tr>
<td>Metal building</td>
<td>0.061</td>
<td>0.123</td>
<td>0.123</td>
<td>0.113</td>
<td>0.113</td>
</tr>
<tr>
<td>Mass 7.0 HC</td>
<td>0.330</td>
<td>0.450</td>
<td>0.450</td>
<td>0.450</td>
<td>0.450</td>
</tr>
<tr>
<td>Mass 15.0 HC</td>
<td>0.360</td>
<td>0.650</td>
<td>0.650</td>
<td>0.650</td>
<td>0.650</td>
</tr>
<tr>
<td>Other</td>
<td>0.074</td>
<td>0.110</td>
<td>0.110</td>
<td>0.102</td>
<td>0.102</td>
</tr>
<tr>
<td><strong>Floor/ Soffit</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-value</td>
<td>19</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>U-factor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass 7.0 HC</td>
<td>0.090</td>
<td>0.139</td>
<td>0.139</td>
<td>0.090</td>
<td>0.090</td>
</tr>
<tr>
<td>Other</td>
<td>0.048</td>
<td>0.071</td>
<td>0.071</td>
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<td>0.071</td>
</tr>
<tr>
<td>R-value</td>
<td>0.47</td>
<td>0.47</td>
<td>0.47</td>
<td>0.47</td>
<td>0.47</td>
</tr>
<tr>
<td><strong>Relative solar heat gain</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-North North</td>
<td>0.46</td>
<td>0.68</td>
<td>0.41</td>
<td>0.61</td>
<td>0.47</td>
</tr>
<tr>
<td>North North</td>
<td>0.46</td>
<td>0.68</td>
<td>0.40</td>
<td>0.61</td>
<td>0.40</td>
</tr>
<tr>
<td>North North</td>
<td>0.36</td>
<td>0.47</td>
<td>0.31</td>
<td>0.61</td>
<td>0.36</td>
</tr>
<tr>
<td>North North</td>
<td>0.36</td>
<td>0.47</td>
<td>0.26</td>
<td>0.55</td>
<td>0.31</td>
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<tr>
<td><strong>Skylights</strong></td>
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</tr>
<tr>
<td>U-factor</td>
<td>1.18</td>
<td>1.42</td>
<td>1.42</td>
<td>1.18</td>
<td>1.18</td>
</tr>
<tr>
<td>Glass w/Curb</td>
<td>0.68</td>
<td>0.82</td>
<td>0.82</td>
<td>0.68</td>
<td>0.68</td>
</tr>
<tr>
<td>Glass w/Curb</td>
<td>1.04</td>
<td>1.56</td>
<td>1.56</td>
<td>1.22</td>
<td>1.04</td>
</tr>
<tr>
<td>SHGC Glass</td>
<td>0.2%</td>
<td>0.46</td>
<td>0.58</td>
<td>0.61</td>
<td>0.46</td>
</tr>
<tr>
<td>SHGC Glass</td>
<td>2.1-3%</td>
<td>0.36</td>
<td>0.32</td>
<td>0.40</td>
<td>0.32</td>
</tr>
</tbody>
</table>

---

**High rise Table 143 B**

HR See p. 84 in 2005 standards
Title 24 Yesterday and Before

- 1998 → 2001 Code
  - 2001 was ~10% more stringent than 1998

- 2001 → 2005 Code
  - On average, 2005 ~15% more stringent than 2001
Time Dependent Valuation (TDV)

- Based on work by PG&E and other investor owned utilities
- Make standards reflect the reality that the cost of energy depends on the hour and season
- TDV changes the way energy is ‘valued’ based on the time of use of that energy
  - Time of day or season no longer irrelevant
  - Higher value for on-peak savings
  - Lower value for off-peak
  - Neutral for savings that are both on & off
With flat energy value a kW saved is valued the same for every hour of the day.

With TDV value a kW saved during a high-cost peak hour is valued more highly than a kW saved during an off-peak hour.

With flat energy value a kW saved is valued the same for every hour of the day.
**TDV Energy Calculation**

- **Energy use values** for the proposed and standard designs are estimated for each hour (8760 hr/yr).

- Each hour of year, energy use estimate multiplied by TDV value for that hour.

  → TDV values vary for each hour of the year, and by

  - **Energy fuel type** (electricity/natural gas/propane)
  - **California climate zone**, and
  - **Building type** (low-rise residential or nonresidential, high-rise residential or hotel/motel)
How does TDV impact the measures that give you credit in T-24?

- TDV favors technologies that save more energy on-peak than off-peak
  - **Greater credit for:**
    - Higher EER air conditioners
    - Lower SHGC glazing
    - Better duct insulation (in unconditioned spaces)
    - Daylighting controls for lighting
  - **Greater penalties for:**
    - West-facing glass
    - Oversized, unshaded windows/skylights
  - **Generally neutral or lower credits for:**
    - Economizers
    - Envelope insulation
    - High efficiency water heating

- *This affects trade-off choices* using the performance approach (computer programs)
On-Site Verification & Maintenance

- On-site verification ensures that buildings are built *per design*
- **HERS Raters** are special inspectors with expertise in energy efficiency measures
- **Verification** and/or **Diagnostic Testing**
- **Building component commissioning**
- **Expect more HERS compliance credit measures**, up to full building commissioning
HERS Measures vs. HERS Verification

- HERS Measures give a project credit in T-24
  → To meet minimum code compliance
  → To exceed the code in the performance approach

- Whether or not any HERS measures have been claimed in T-24, a HERS Rater must be used to certify a residential project at 15% above code for Utility Program purposes
HERS Measures that give credit in T-24

- High EER for AC
- Quality Insulation Installation (QII)
- Maximum cooling capacity
- Duct surface area and R-value
- Air handler Fan Watt Draw
- Supply duct location and deeply buried ducts
Upcoming 2008 Title 24 Standards

- Lower prescriptive U-factors for windows
- Additional HERS measures
- Required ventilation in residential code
- Minimum prescriptive reflectivity of roof materials in specific CZ
- Opaque building elements have different default assumptions in non-res calculations methods
- Improved controls required for outdoor site-lighting
- Demand response programmable thermostats

*Will be in place April, 2009*
Multifamily New Homes: High Performance Energy Efficiency Design

What Measures in 2005 Standards achieve a ~15% Compliance Margin?
What Measures are Necessary?

- Measures vary by building type
  - High-rise versus low-rise
  - Central versus distributed systems
  - Amount of building self shading
  - Building geometry

- Measures vary by climate zone
  - Focus on measures affecting largest energy use
  - Peak demand related measures first
Primary Energy Efficiency Design

Decisions: Order of Consideration for MF projects

- Determine **Occupancies**
- **Central vs. Individual** systems
- % **Glazing**
  - Orientation
- **Envelope** Improvements
  - Insulation
  - Windows
  - HERS Measures
- **Mechanical** Efficiency Upgrades
How Do We Make MF Units More Energy Efficient?

- **Envelope**
  - “High performance” Windows
  - Properly installed insulation
  - Air tight envelope

- **Water heating**
  - Central systems
  - Smart controls
  - High efficiency

- **High efficiency HVAC systems**
  - Maximize equipment efficiency
  - Minimize distribution losses
  - Size equipment correctly

- **Whole Building Design**
Going Beyond Heating, Cooling and Water Heating

- **Appliances**
  - ENERGY STAR
  - Refrigerator
  - Washer
  - Dishwasher
  - Dryer - Gas!

- **Water**
  - Low flow
  - H-Axis washer

- **Lighting**
  - T-8s and electronic ballasts
  - CFLs - Compact Fluorescent Lamps
  - Reflector bulbs in “can” lights
  - Occupancy sensors
Measures for Low-rise vs. High-rise

- For both high-rise & low-rise measures vary by:
  - Climate Zone (Coastal or Inland)
  - Primary Energy Efficiency Design Decisions mentioned in last slide

- High-rise projects
  - Don’t receive credit for most HERS measures
    - Since envelope and HVAC are non-residential
    - Measure that do impact: duct testing, *not QII, ducts in conditioned space, etc*
    - Therefore No ENERGY STAR® designation
  - Roof measures have less impact
  - DHW higher percentage of total budget
  - Metal Framing and high framing factors = need more insulation
Multifamily New Homes: High Performance Energy Efficiency Design

Title 24 & Building Envelope

Methods and Measures Part I

Sponsored by
Southern California Edison

Presented by the
Heschong Mahone Group, Inc.

AFFORDABLE HOUSING ENERGY EFFICIENCY ALLIANCE
# Energy Design Measures

<table>
<thead>
<tr>
<th>Site Considerations</th>
<th>Energy Design Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate</td>
<td></td>
</tr>
<tr>
<td>Solar Access</td>
<td></td>
</tr>
<tr>
<td>Orientation with relation to the sun and wind</td>
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<table>
<thead>
<tr>
<th>Building Envelope Options</th>
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<tbody>
<tr>
<td>Insulation: R-value &amp; Quality of Installation</td>
<td></td>
</tr>
<tr>
<td>Radiant Barrier / Cool Roof</td>
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<tr>
<td>Attic venting</td>
<td></td>
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<tr>
<td>Windows and glazing</td>
<td></td>
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<tr>
<td>Shading of building and windows (vegetation, overhangs, etc)</td>
<td></td>
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<tr>
<td>Thermal mass</td>
<td></td>
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<tr>
<td>Infiltration / exfiltration</td>
<td></td>
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<table>
<thead>
<tr>
<th>HVAC Equipment</th>
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<tr>
<td>Space heating</td>
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<tr>
<td>Space cooling</td>
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<tr>
<td>Correct sizing</td>
<td></td>
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<tr>
<td>Quality installation</td>
<td></td>
</tr>
<tr>
<td>Distribution</td>
<td></td>
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<table>
<thead>
<tr>
<th>Water Heating System</th>
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<tbody>
<tr>
<td>Central or individual</td>
<td></td>
</tr>
<tr>
<td>Storage or tankless</td>
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<tr>
<td>Distribution controls</td>
<td></td>
</tr>
<tr>
<td>Location(s)</td>
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<tr>
<td>Central laundry or in-unit</td>
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<table>
<thead>
<tr>
<th>Lighting</th>
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<tr>
<td>Hardwired High Efficacy Interior Lighting Fixtures w/ Controls</td>
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<tr>
<th>Appliances</th>
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<tbody>
<tr>
<td>ENERGY STAR® Dishwashers (IF .58-37, IF .63 or greater)</td>
<td></td>
</tr>
<tr>
<td>ENERGY STAR® Refrigerators (must exceed current federal standard by 10%)</td>
<td></td>
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<tr>
<td>ENERGY STAR® Clothes washers (IF 2.0; WF 0.6-4.0; MIF 2.2 or greater; WF 4.6 or less)</td>
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<tr>
<td>Natural gas clothes dryers</td>
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</table>

<table>
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<th>Operations &amp; Maintenance</th>
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</thead>
<tbody>
<tr>
<td>(leave a guide on how to properly maintain and operate high performance equipment)</td>
<td></td>
</tr>
</tbody>
</table>

| Water efficiency                             |                        |
Building Efficiency Measures

A. Site Considerations

B. Building Envelope

C. Lighting
Site Considerations

- Climate Zone
- Sun (orientation)
- Wind
  - Stack effect
  - Cross ventilation
- Site Energy Generation
California’s Climate Zones

- Not typical climate zones, e.g. “alpine” or “desert”
- Based on combination of energy use, temperature, weather data and other factors
- A geographic area grouped for the purpose of creating an “energy budget”
- The energy budget is the maximum energy a building can consume in one year
California Climate Zones

Coastal Climate Zones: 1-7
Inland Climate Zones: 8-16
Cooling-Dominated Climate Zones

2005
Site Influences

- Sun and Wind are most important site influences.
- Buildings interact with them primarily through shape, shade and the material properties of the building envelope, e.g:
  - Solar transmittance of windows
  - Air infiltration properties of building envelope
  - Reflectivity and emissivity of outer surfaces
Passive Wind Design

Cross Ventilation for Free Cooling

- Inlet, **without** outlet
  - Breeze will not readily enter space

- Inlet **and** outlet
  - Cross ventilation
  - Stack effect improves flow
Passive Wind Design

Taking Advantage of the Stack Effect

Window or roof opening higher than inlet opening

→ Warm air rises and exhausts
→ Cool air drawn in through lower openings and replaces warm air
Situating the Building

- **Building Orientation**
  - Short faces of building East-West
  - Long faces of building facing North-South

- Use inter-building shading to minimize afternoon solar heat gain

- Sloped roofs facing south for eventual site generation (solar-thermal and photovoltaics)
Shading Devices

- Proper sizing of overhangs
  - Sun position calculator
  - determine azimuth and angles
  - www.geocities.com/senol_gulgonul/sun/

- Building-integrated landscaping

- Plant deciduous trees on the south side

- Use photovoltaic panels for shading
Site Energy Generation

- Photovoltaics (solar electric)
- Solar Water Heating (solar thermal)
- Wind Power
- Fuel Cells
- MicroTurbines
- Net Metering
Colorado Court, Santa Monica

- 44-unit Single Resident Occupancy building
- Designed for 100% energy independence
- 27.4 kW\textsubscript{CEC} rated PV system
  - 204 modules @ 140 watts
  - Modules shade building
- Roof-mounted natural gas-fired 30 kW microturbine
  - Generates electricity and uses waste heat for space and water heating
Model Low-Income Housing

- Passive solar first!
  - Orientation to control solar cooling loads
  - Shading of south facing windows; minimize west facing
  - Shape for exposure to prevailing winds (natural ventilation)
  - Window design to maximize natural ventilation
  - Interior design to enhance daylighting and natural air flow
Building Efficiency Measures

A. Site Considerations

B. Building Envelope

C. Lighting
Building Envelope Measures

- Insulation
- Windows, Doors, Skylights
- Radiant Barriers
- Thermal Mass
Insulation Basics

- Insulation resists the flow of heat
- Measured by R-value (R = Resistance)
- In some climate zones, a radiant barrier over “standard practice” insulation is more effective than a higher insulation R-value
- Better insulation can help reduce HVAC equipment size
**Insulation Types**

- Fibrous Insulation
  - Blankets
  - Batts
  - Loose-fill
- Spray Foam
- Rigid Foam Panels
- Insulating Concrete Forms (ICF)
- Foam Core Concrete Panels
Insulation Issues

- Standard practice = Poor installation
  - Gaps and voids
  - Not in contact with air barrier (drywall)
  - Compression
- = “Thermal Bypass”
- Insulation is cost effective—*when* installed correctly
New ENERGY STAR Insulation Requirements: TBC/QII

- Blower door tests measure air infiltration and verify the tightness of the building envelope
- But, EPA found that many tight buildings were losing more heat than expected
- Further investigations with infrared cameras uncovered what is now comprehensively called the Thermal Bypass
- Thermal Bypass Checklist is now a requirement for the ENERGY STAR label
2005 Insulation Changes

- Effective R-value significantly less in 2005 for “standard” insulation installation
- New “joint appendix” for wall assemblies
- Verified quality installation provides benefits over standard installation

→ But still has lower R-value compared to 2001 Title 24 standards
## Insulation Quality Impact

### Comparison of Insulation Values Between 2001 and 2005 Energy Standards

<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Labeled R-Value</td>
<td>U-Factor</td>
<td>Equivalent R-Value</td>
</tr>
<tr>
<td>R-13</td>
<td>0.088</td>
<td>11.4</td>
<td>8.2</td>
</tr>
<tr>
<td>R-15</td>
<td>0.081</td>
<td>12.3</td>
<td>8.8</td>
</tr>
<tr>
<td>R-19</td>
<td>0.065</td>
<td>15.4</td>
<td>11.4</td>
</tr>
<tr>
<td>R-21</td>
<td>0.059</td>
<td>16.9</td>
<td>12.2</td>
</tr>
</tbody>
</table>
Old Assumptions

15% Framing – 16" on center studs
Realistic Basis for a Framing Factor
Insulation: the Air Barrier

Insulation can look OK at first glance…

But batts NOT installed in contact w/ air barrier

Source: Doug Beaman, Douglas Beaman Associates
Insulation: Wiring and Plumbing

- Behind boxes and wiring
- Compressed
- Gaps and Voids

Source: Doug Beaman, Douglas Beaman Associates
Quality Insulation Installation (QII)

- Changes in 2005 Title 24
  - Std installation of insulation: R-value de-rated by 13%
  - Quality Insulation Installation: full R-value rating

- HERS Rater inspects for QII:
  - Fully lofted and filled framing cavities (no compression)
  - Full contact with air barrier
  - Rim joists insulated
  - Batts butt-fit or split around wiring and plumbing
  - Wall cavities caulked or foamed for air-tight seal
  - Pre-insulation of hard to access wall stud cavities
  - Knee walls and skylight shafts insulated to min. R-19
  - Insulation over all recessed lighting fixtures
Cellulose Spray Insulation

- Fills irregular spaces
- Flush with air barrier

Source: Doug Beaman, Douglas Beaman Associates

- No cutting and splitting
- But, must allow to dry
Insulation

- In continuous contact with air barrier
- No gaps
- No compressions
- No voids
Infiltration / Exfiltration

- Air leakage through wall can cause substantial energy loss
  - House wrap
  - Blower door test for leakage
Windows and Glazing

- Select based on NFRC* performance values
- Design appropriate shading devices
- If you can’t shade, then minimize SHGC*
- Minimize U-factors, e.g. dual pane glazing
- Better windows can help reduce heating and cooling equipment size – saving first costs

* NFRC = National Fenestration Ratings Council
* SHGC = Solar Heat Gain Coefficient
NFRC Window Label

National Fenestration Rating Council (NFRC)

→ Window energy rating system based on whole product performance
→ Required during building inspection

the only reliable way to determine window energy properties and to compare products

<table>
<thead>
<tr>
<th>World's Best Window Co.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Millennium 2000+</td>
</tr>
<tr>
<td>Vinyl-Clad Wood Frame</td>
</tr>
<tr>
<td>Double Glazing • Argon Fill • Low E</td>
</tr>
<tr>
<td>Product Type: Vertical Slider</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ENERGY PERFORMANCE RATINGS</th>
<th>ADDITIONAL PERFORMANCE RATINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-Factor (U.S./I-P)</td>
<td>Solar Heat Gain Coefficient</td>
</tr>
<tr>
<td>0.34</td>
<td>0.25</td>
</tr>
<tr>
<td>Visible Transmittance</td>
<td>Air Leakage (U.S./I-P)</td>
</tr>
<tr>
<td>0.41</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. Consult manufacturer’s literature for other product performance information.

www.nfrc.org
What to Look For: Performance

- U-factor of 0.40, or less
- SHGC of 0.36, or less
- Visible light transmittance (VLT) of 0.50 or more
- Low emissivity (Low E)
  - Reduces U-factor (heat loss) and SHGC (heat gain)

Low-emittance (Low-E) coatings are deposited on a window to reduce the U-factor by suppressing radiative heat flow.
What to Look for: Technologies

- **Window Technologies:****
  - Spectrally selective, low-E insulating glass
  - Vinyl, composite or thermal-break aluminum frames
  - Insulating spacers

- **Cardinal LoE³-366 Glass**
  whole window, vinyl frame:
  - U-factor = 0.34
  - SHGC = 0.20
  - VT = 0.43
  (varies by window type; average values)

Low-E coatings:
- Reduce solar heat gain in the summer
- Reduce heat loss in the winter
High Rise Fenestration

- Buildings with more than 10,000 ft\(^2\) of site built vertical fenestration are required to have the fenestration certified under the NFRC-100SB rating and labeling procedures.

- Larger high-rise apartment buildings may trigger this requirement - at about 100,000 ft\(^2\) [assuming 10% fenestration to floor area ratio].
2005 Code Fenestration Issues

- Allowable west-facing glass is limited to 5% of floor area (performance trade-off)

- Standard multifamily design is based upon actual glazing area instead of 16% or 20% (up to 20%)

- Fenestration U-factors changed
Radiant Barrier

- Most effective in cooling-dominated zones
- Can complement ceiling insulation with a lower R-value
- Cost per sq ft coming down rapidly
- Does not carry heating penalty of cool roofs
Radiant Barrier

• Types
  → Single-sided foil stapled to roof joists (retrofit)
  → Foil-faced roof sheathing (new construction)

• Installation
  → Must be adjacent to air gap
  → Must face down--to avoid dust accumulation

• Benefits
  → Reduces attic air temperature by 30-50 degrees
  → Reduced heat gain in duct work
  → No additional labor costs (new construction)
Thermal Mass

Thermal mass as a design element

- Reduces interior temperature swings
- Absorbs heat during the day and re-emits at night (reduces heating demand in winter)
- Releases heat at night and re-absorbs during the day (reduces cooling demand in summer)
- Works best when mass is directly exposed to the interior air mass and in climates with large daily temperature swings
Building Efficiency Measures

A. Site Considerations

B. Building Envelope

C. Lighting
Lighting Overview

Lighting

→ Terminology
→ Title 24
→ Equipment
Lighting Industry Terminology

- **Lamp** = Light Bulb
- **Lumen** = A unit of Visible Light
- **Luminaire** = Light Fixture
- **Efficacy** = efficiency of lighting product (Lumens/watt)

Picture Source: National Renewable Energy Laboratory
• 2005 CEC Definition of “High Efficacy“
  → No screw-based fixtures meet the definition
  → Must have electronic ballasts if > 13 watts

<table>
<thead>
<tr>
<th>Lamp Power Rating</th>
<th>Minimum Lamp Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 watts or less</td>
<td>40 lumens per watt</td>
</tr>
<tr>
<td>over 15 watts to 40 watts</td>
<td>50 lumens per watt</td>
</tr>
<tr>
<td>over 40 watts</td>
<td>60 lumens per watt</td>
</tr>
</tbody>
</table>
Lighting and Title 24

- Mandatory measures:
  - Lighting requirements are all mandatory
  - Not part of prescriptive package
  - Not part of residential energy performance calculation budget
  - Primarily impacts dwelling units
  - The Standards apply only to permanently installed luminaires
“High Efficacy” fixtures required in almost all rooms

- Kitchens: Minimum 50% of installed Lighting
- Bathrooms, Garages, Laundry & Utility Rooms: High Efficacy or have occupant sensor
- Other rooms (hallways, dining rooms, family rooms & bedrooms, etc.): High Efficacy or have occupant sensor (or dimmer)
- Outdoor Lighting: High Efficacy or shall be controlled by a photocontrol/motion sensor combination
2005 Lighting Code Summary

- **Multifamily Common Areas (Low Rise)**
  - High efficacy luminaires OR have occupancy sensors
  - High Rise – Nonresidential Standards apply

- **Parking lot lighting, for more than 8 cars are required to meet Nonresidential Standards**
  - Lamps over 100 W = 60 lumens/watt OR have a motion sensor
  - Lamps over 175 W must be “cut-off” rated
  - Luminaires must be controlled by photocontrol OR astronomical time switch
2005 Code Details

**Kitchens**

→ 50% of the installed **watts** must be “high efficacy” fixtures

→ Wattage determined by the maximum rated wattage of the fixture (not lamp) times the total number of lamps.
2005 Code Details

- Recessed fixtures in insulated ceilings
  - Must be Insulated Cover (IC) - rated for direct contact with insulation
  - Must be “air tight” (AT)
  - Beware electronic ballasts not designed for high temperatures found in attic spaces
Other 2005 Code Details

- Common Areas (hallways, lobbies, corridors, stairwells)
  - must be high efficacy or controlled by an occupancy sensor
Other 2005 Code Details

- Screw-in, “modular” Compact Fluorescent Lamps (CFLs) **not** allowed
- Must use pin-based, “hardwired” compact fluorescent fixtures
- Electronic Ballasts
- Occupancy Sensors
- Motion sensor/photocell
Screw-in Compact Fluorescent Lamps

- “High Efficacy” fixtures
- Energy Star labeled fixtures
- Pin-based equipment not sold in grocery stores
Lighting Equipment

- Wide variety of types and sizes available
Lighting Controls

- Dimmers
- Occupancy
- Photosensors
- Timers
- Motion Sensors
California Kitchen Lighting System

- Funded by CEC
- Partners include SMUD, Lithonia, CLTC (California Lighting Technology Center) and others
- Product commercially available by Lithonia
- 50 lumens per watt (high efficacy)
- One ballast operating two fixtures
- Fixture costs reduced by over 50%
- High output lamps (26 watts CFL)
Lithonia “CKP” Recessed Fixtures

California Kitchen Lighting System Residential kitchen demo
LED Lighting: The Future?

- Light Emitting Diode
- Approx 20 lumens per watt
- Can be installed:
  - Under counters
  - Hallways, staircases
- Still Limited by Production
- Stay Tuned!
Lighting Manufacturers

- Sunpark Lighting
- Brownlee Lighting
- Sea Gull Lighting
- Access Lighting
- American Fluorescent Corp.
- ASL Energy Efficient Lighting
- LaMar Lighting
- Lithonia
- Progress Lighting

- All other manufacturers (including decorative) can retrofit existing lamps on a special order basis