We’ll be starting in just a few minutes….

Visit our new Online Learning Series webpage on the Solution Center where you can see the schedule of upcoming webinars, RSVP, and access previously recorded webinars on other energy management topics.
Online Learning Series – Webinar #3
Lighting, HVAC, and Building Envelope

Eli Levine
Office of Energy Efficiency and Renewable Energy
Eli Levine
U.S. Department of Energy
<table>
<thead>
<tr>
<th>Webinar Topic</th>
<th>Speaker</th>
<th>Date</th>
<th>Time</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better Plants Town Hall</td>
<td>Eli Levine (DOE), feat. Al Hildreth (General Motors)</td>
<td>04/16/20</td>
<td>1:00 pm US-EST</td>
<td>Register</td>
</tr>
<tr>
<td>Basics of Energy</td>
<td>Thomas Wenning (ORNL)</td>
<td>04/23/20</td>
<td>1:00 pm US-EST</td>
<td>Register</td>
</tr>
<tr>
<td>Lighting, HVAC, and Building Envelope</td>
<td>Thomas Wenning (ORNL)</td>
<td>04/29/20</td>
<td>1:00 pm US-EST</td>
<td>Register</td>
</tr>
<tr>
<td>Resources You Should Know: USDA Rural Development Programs and the Department of Commerce Manufacturing Extension Partnership</td>
<td>Venus Welch-White (USDA) and David Stieren (NIST-MEP)</td>
<td>05/07/20</td>
<td>1:00 pm US-EST</td>
<td>Register</td>
</tr>
<tr>
<td>Compressed Air Systems</td>
<td>Thomas Wenning (ORNL)</td>
<td>05/14/20</td>
<td>1:00 pm US-EST</td>
<td>Register</td>
</tr>
<tr>
<td>Water Efficiency</td>
<td>Sachin Nimbalkar (ORNL)</td>
<td>05/21/20</td>
<td>1:00 pm US-EST</td>
<td>Register</td>
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</tbody>
</table>
In case you missed it…

Watch Week 1

Online Learning Series – Webinar #1
Better Plants Town Hall
Eli Levine
Office of Energy Efficiency and Renewable Energy

Watch Week 2

Online Learning Series – Webinar #2
Basics of Energy
Eli Levine
Office of Energy Efficiency and Renewable Energy
JUNE 8–11
2020 SUMMIT
A Virtual Leadership Symposium

Learn more and register: betterbuildingssolutioncenter.energy.gov/summit
Tom Wenning
Oak Ridge National Lab
Lighting HVAC and Building Envelope

Thomas Wenning, PE
Session Outline

- **Lighting**
  - Lighting units of measurement
  - Lamp types
  - Recommended light levels
  - Energy savings opportunities

- **HVAC**
  - Major equipment
  - HVAC energy efficiency measures
  - Energy savings opportunities

- **Building Envelope**
  - Building envelope components
  - Insulation and windows ratings
  - Energy savings opportunities
Lighting Units of Measurement

- **Power input**
  - Watt

- **Light output**
  - Lumen

- **Light level**
  - Foot-candle (Lumens/Ft²)
  - Lux (Lumens/M²)
  - 1 Foot candle = 10.8 Lux

- **Efficacy**
  - Light output/Power input
  - Lumen/Watt (LPW)

- **CRI**
  - Color Rendering Index
  - Great: >=90; Good: >=60, <90; Poor: <60

*Turner, W., Energy Management Handbook*
Lighting

- Lamps
  - Incandescent
  - Compact fluorescent lamp (CFL)
  - Fluorescent
  - High intensity discharge
    - Mercury vapor
    - Metal halide
    - High pressure sodium
  - LED

http://www.mustanglighting.com
Lighting

- **Incandescent**
  - Efficacy – 15-25 LPW
  - Life – 750-12,000 hours
  - Lowest price

- **Fluorescent**
  - Efficacy: 55-100 LPW
  - Life: 7,500 – 24,000 hours
  - A wide variety of styles
  - T5 & T8 most common for commercial buildings

http://wholesalelightinginc.com
Lighting

- **Mercury Vapor (MV)**
  - Efficacy: 50 – 60 LPW
  - Life: 15,000 – 16,000 hours
  - Poor color rendering index (CRI)

- **Metal Halide**
  - Efficacy: 80-100 LPW
  - Life: 1,500 – 15,000 hours
  - Improved CRI
  - 1 to 15 minutes warm up time

- **High Pressure Sodium**
  - Efficacy: 75-140 LPW
  - Life: 24,000 hours
  - Poor CRI
  - Exterior lighting and some indoor application

http://wholesalelightinginc.com
Lighting

- **LED**
  - Efficacy: ~100 LPW
  - Life: 50,000 hours
  - Great CRI
  - Mature technology
  - Bulbs, tubes, etc.
  - Plug and play
  - Acceptable payback
  - **Best option!**

http://wholesalelightinginc.com
# Lighting Comparison

<table>
<thead>
<tr>
<th>Lamp Type</th>
<th>LED</th>
<th>Incandescent</th>
<th>Halogen</th>
<th>Fluorescent</th>
<th>CFL</th>
<th>HID</th>
<th>Metal Halide</th>
<th>HPS</th>
<th>LPS</th>
<th>Mercury Vapour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Conversion Efficiency</td>
<td>90%</td>
<td>5 - 10%</td>
<td>5 - 10%</td>
<td>25%</td>
<td>40%</td>
<td>25%</td>
<td>30%</td>
<td>30%</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>Average Lifespan</td>
<td>50K hours</td>
<td>1 - 2K hours</td>
<td>2 - 4K hours</td>
<td>7 - 15K hours</td>
<td>7 - 10K hours</td>
<td>6 - 20K hours</td>
<td>≤24K hours</td>
<td>≤16K hours</td>
<td>≤16K hours</td>
<td></td>
</tr>
<tr>
<td>Power Consumption</td>
<td>Low</td>
<td>Very High</td>
<td>Very High</td>
<td>High</td>
<td>Mid</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Maintenance Cost</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Efficacy</td>
<td>65 - 160 lm/W</td>
<td>12 lm/W</td>
<td>18 lm/W</td>
<td>80 lm/W</td>
<td>60 lm/W</td>
<td>65 - 115 lm/W</td>
<td>50 - 90 lm/W</td>
<td>50 - 90 lm/W</td>
<td>30 - 65 lm/W</td>
<td></td>
</tr>
<tr>
<td>Color Temperature</td>
<td>2,700 - 10,000K</td>
<td>2,500 - 2,700K</td>
<td>3,000 - 3,200K</td>
<td>2,700 - 6,000K</td>
<td>2,700 - 6,000K</td>
<td>3,000 - 20,000K</td>
<td>1,900 - 2,200K</td>
<td>2,200K</td>
<td>2,200K</td>
<td></td>
</tr>
<tr>
<td>CRI</td>
<td>65 - 95</td>
<td>&gt;90</td>
<td>&gt;90</td>
<td>&gt;80</td>
<td>80 - 90</td>
<td>&gt;60</td>
<td>&gt;60</td>
<td>40 - 60</td>
<td>40 - 60</td>
<td></td>
</tr>
<tr>
<td>Flicker</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>UV Radiation</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Lead content</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Selective Yes</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Mercury</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Infra Red Radiation</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

[https://electrical.school/](https://electrical.school/)
Lumen Depreciation Over Time

https://www.kambo.com
Color Rendering Index

Underlit

- Reduce workers’ comfort
- Reduce workers’ productivity
- Potential safety issues
- Potential production shutdown

Overlit

- Common in most buildings
- Reduce workers’ comfort
- Reduce workers’ productivity
- Waste energy

---

### Table 13.1 Recommended light levels for visual tasks.

<table>
<thead>
<tr>
<th>Building/Space Type</th>
<th>Guideline Illuminance Range (footcandles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial interiors</td>
<td></td>
</tr>
<tr>
<td>Art galleries</td>
<td>30-100</td>
</tr>
<tr>
<td>Banks</td>
<td>50-150</td>
</tr>
<tr>
<td>Hotels (rooms and lobbies)</td>
<td>10-50</td>
</tr>
<tr>
<td>Offices</td>
<td>30-100</td>
</tr>
<tr>
<td>- Average reading and writing</td>
<td>50-75</td>
</tr>
<tr>
<td>- Hallways</td>
<td>10-20</td>
</tr>
<tr>
<td>- Rooms with computers</td>
<td>20-50</td>
</tr>
<tr>
<td>Restaurants (dining areas)</td>
<td>20-50</td>
</tr>
<tr>
<td>Stores (general)</td>
<td>20-50</td>
</tr>
<tr>
<td>Merchandise</td>
<td>100-200</td>
</tr>
<tr>
<td>Institutional interiors</td>
<td></td>
</tr>
<tr>
<td>Auditoriums/assembly places</td>
<td>15-30</td>
</tr>
<tr>
<td>Hospitals (general areas)</td>
<td>10-15</td>
</tr>
<tr>
<td>Labs/treatment areas</td>
<td>50-100</td>
</tr>
<tr>
<td>Libraries</td>
<td>30-100</td>
</tr>
<tr>
<td>Schools</td>
<td>30-150</td>
</tr>
<tr>
<td>Industrial interiors</td>
<td></td>
</tr>
<tr>
<td>Ordinary tasks</td>
<td>50</td>
</tr>
<tr>
<td>Stockroom storage</td>
<td>30</td>
</tr>
<tr>
<td>Loading and unloading</td>
<td>20</td>
</tr>
<tr>
<td>Difficult tasks</td>
<td>100</td>
</tr>
<tr>
<td>Highly difficult tasks</td>
<td>200</td>
</tr>
<tr>
<td>Very difficult tasks</td>
<td></td>
</tr>
<tr>
<td>Most difficult tasks</td>
<td></td>
</tr>
<tr>
<td>Exterior</td>
<td></td>
</tr>
<tr>
<td>Building security</td>
<td>1.5</td>
</tr>
<tr>
<td>Floodlighting (low/high brightness or surroundings)</td>
<td>5-30</td>
</tr>
<tr>
<td>Parking</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Turner, W., Energy Management Handbook, Recommendations from IEES
Lighting Level Requirements

  - **Type of task** being performed
  - **Size of objects** handled
  - **Level of detail** required
  - Average **age of workers** in that space
- More light needed for tasks involving **smaller size** and **lower contrast**
- Adjust for age of worker
## Lighting Level Recommendations

- **Ordinary tasks:** 50 fc
- **Stockroom storage:** 30 fc
- **Loading and unloading:** 20 fc
- **Difficult tasks:** 100 fc
- **Highly difficult tasks:** 200 fc
- **Very difficult tasks:** 300-500 fc
- **Most difficult tasks:** 500-1000 fc

### Building Area & Task

<table>
<thead>
<tr>
<th>Building Area &amp; Task</th>
<th>Average Maintained Footcandles (Horizontal) (FC)</th>
<th>Range of Maintained Footcandles (Horizontal) (FC)</th>
<th>Average Maintained Footcandles (Vertical) (FC)</th>
<th>Range of Maintained Footcandles (Vertical) (FC)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INDUSTRIAL/MANUFACTURING</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assembly</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple (Large Item)</td>
<td>30</td>
<td>15 - 60</td>
<td>30</td>
<td>15 - 60</td>
</tr>
<tr>
<td>Difficult (fine)</td>
<td>100</td>
<td>50 - 200</td>
<td>100</td>
<td>50 - 200</td>
</tr>
<tr>
<td>Component Manufacturing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>30</td>
<td>15 - 60</td>
<td>30</td>
<td>15 - 60</td>
</tr>
<tr>
<td>Medium</td>
<td>50</td>
<td>25 - 100</td>
<td>50</td>
<td>25 - 100</td>
</tr>
</tbody>
</table>
Savings Opportunities

- **Upgrade lighting types**
  - LED (~60-80% savings comparing to Metal Halide)

- **Occupancy sensors**
  - Switches, Timers, Photocells & Occupancy Sensors
  - Areas with less traffic (storage)
  - Dimming

- **Avoid over lighting**
  - Check after lighting upgrade
  - Reduce number of light fixtures

- **Use spot lighting**
  - Do not light the entire area
Daylight

- Advanced Polycarbonate wall
- Skylight
- Daylight tube

https://static-assets-solatube.s3.amazonaws.com
HVAC

- Heating, ventilating and air-conditioning
- Control the environment for people and equipment

- Purposes
  - Temperature
  - Humidity
  - Air movement
  - Indoor air quality
Thermal comfort range

- **Temperature**
  - 68 F to 76 F

- **Humidity**
  - 40% to 69% Relative Humidity

- **Air Quality**
  - Odor removal
  - **Fresh air** quantity (ASHRAE 62.1)
Psychrometric Chart

http://ecavelier.files.wordpress.com
**Major HVAC Equipment**

- **Chillers** *(Training Session 5)*
  - Chilled Water (~43 F)

- **Air handling units**
  - Cold air (~55 F)

- **Make-up air units**
  - Replace exhausted air

- **Circulation fans**
  - Moving air

- **Exhaust fans**
  - Mech./Elec. rooms

- **Unit heater**
  - Mech. rooms

- **Boilers** *(Training Session 5)*
  - Hot water (~180 F)

---

**Resources**

[www.carrier.com](http://www.carrier.com)
[www.homedepot.com](http://www.homedepot.com)
[www.kamfri.com](http://www.kamfri.com)
AHUs

https://i.pinimg.com
Power and Energy in HVAC

- **1 Ton Cooling:**
  - Defined as the rate of energy that results in the *freezing* (*or melting*) of **1 short ton (2,000 lb)** of pure ice at **0 °C (32 °F)** in 24 hours.
  - **1 Ton Cooling = 12,000 Btu/hr**
  - **1 Ton Cooling = 3.517 kW**
  - The most common **unit** for equipment size

[Image: What is a Refrigeration Ton]

[Link: https://www.youtube.com]
Vapor Compression Cycle

Condenser

Compressor

Expansion Valve

Evaporator
Air Conditioner Energy Efficiency Measures

- **EER**: Energy Efficiency Rating
- **SEER**: Seasonal Energy Efficiency Rating

- The average **EER** of ENERGY STAR Most Efficient 2019 is 13.7
- The average **SEER** of ENERGY STAR Most Efficient 2019 is 19.4
Air Conditioner Energy Efficiency Measures

\[
\text{EER} = \frac{\text{Btu of cooling output}}{\text{Wh of electric input}}
\]

\[
\text{COP} = \frac{\text{Energy of cooling output}}{\text{Energy of electric input}}
\]

\[
\text{COP} = \frac{\text{EER}}{3.412}
\]

\[
\frac{\text{kW}}{\text{ton}} = \frac{\text{kW of energy electric input}}{\text{ton of cooling output}} = \frac{12}{\text{EER}} = \frac{3.517}{\text{COP}}
\]

\[
\text{SEER} = \text{the average EER for the whole season}
\]
Heat Pump Energy Efficiency Measures

**HSPF** = \( \frac{\text{Btu of heating output}}{\text{Wh of electric input}} \)

**COP** = \( \frac{\text{Energy of heating output}}{\text{Energy of electric input}} \)

\[ \text{COP} = \frac{\text{HSPF}}{3.412} \]

- The average **HSPF** of ENERGY STAR Most Efficient 2019 is 11.0
Savings Opportunities for AHUs

- **Control setpoint reset**
  - 80°F for cooling; 65°F for heating when unoccupied

- **Avoid**
  - Over-heating
  - Over-cooling
  - Over-dehumidification
  - Over-ventilating
Savings Opportunities for AHUs

- **VFD** on fan control
- Fan **pressure setpoint reset**
- **Filter** maintenance
  - Save fan power
- Identify **reheat valve leakage**
- **More efficient units**
  - Higher EER, SEER
Savings Opportunities for AHUs and RTUs

- Air Economizers
- Energy Recovery Wheels
Savings Opportunities for Exhaust Fans

- Do not run 24/7
- Turn off when not needed
- Control based on temperature or humidity
- Install VFD
- Utilize notched v-belts
- Avoid over-exhausting

www.kamfri.com
Savings Opportunities for Circulation Fans

- Do not run 24/7
- Turn off when not needed
- Control based on temperature or humidity
- Install VFD
- Avoid over-circulating
Savings Opportunities for Unit Heaters

- Do not run 24/7
- Turn off when not needed
- Control based on temperature
- Avoid over-heating
- Use infrared heater for spot heating, high ceilings and near dock doors

https://www.hummert.com  https://s3-assets.sylvane.com/
Building Envelope

- **Exterior Walls**
- **Roofs**
- **Windows**
- **Exterior Doors**
- **Divider** between conditioned and unconditioned areas
- **Interior Walls** around specially conditioned spaces
Opportunities for building envelope are different than commercial buildings in several important ways:

- Some manufacturing facilities don’t require heat
- Many manufacturing facilities are not cooled (this is changing though)
- Ventilation rates remove much heat (and cooling)
Insulation Ratings

- **R-value**
- The higher, the more thermal resistance
- **R-value** depends on the *type* of insulation, *thickness*, and density
- **1 inch of solid wood** has an **R-value** of 1
- **1 inch of blown cellulose** in an attic has an **R-value** of 3.2 - 3.7

https://www.thebalancesmb.com/
Insulation Assessment

https://www.amazon.com

https://aaffordableinsulators.com/
Windows Ratings

- **U-factor**
  - The lower, the more insulation

- **SHGC**
  - The lower, the less sun coming in

- **Visible Transmittance**
  - The lower, the less visible light coming in

- **Air Leakage**
  - The lower, the less leakage
### Typical Windows Ratings

<table>
<thead>
<tr>
<th>Frame Type</th>
<th>Glazing Type</th>
<th>Unlabeled Vertical Fenestration</th>
<th></th>
<th>Clear Glass</th>
<th>Tinted Glass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>U-Factor</td>
<td>SHGC</td>
</tr>
<tr>
<td>All frame types</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Single glazing</td>
<td></td>
<td></td>
<td>1.25</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>Glass block</td>
<td></td>
<td></td>
<td>0.60</td>
<td>0.56</td>
</tr>
<tr>
<td>Wood, vinyl, or fiberglass frames</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Double glazing</td>
<td></td>
<td></td>
<td>0.60</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>Triple glazing</td>
<td></td>
<td></td>
<td>0.45</td>
<td>0.52</td>
</tr>
<tr>
<td>Metal and other frame types</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Double glazing</td>
<td></td>
<td></td>
<td>0.90</td>
<td>0.68</td>
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<tr>
<td></td>
<td>Triple glazing</td>
<td></td>
<td></td>
<td>0.70</td>
<td>0.60</td>
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</tbody>
</table>

*Source: ASHRAE 90.1*
## BuildingEnvelopeRequirements

### TABLE 5.5-5 Building Envelope Requirements For Climate Zone 5 (A, B, C)*

<table>
<thead>
<tr>
<th>Opaque Elements</th>
<th>Nonresidential</th>
<th>Residential</th>
<th>Semiheated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assembly Max.</td>
<td>Insulation Min. R-Value</td>
<td>Assembly Max.</td>
</tr>
<tr>
<td><strong>Roofs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation Entirely above Deck</td>
<td>U-0.048</td>
<td>R-20.0 c.i.</td>
<td>U-0.048</td>
</tr>
<tr>
<td>Metal Building</td>
<td>U-0.065</td>
<td>R-19.0</td>
<td>U-0.065</td>
</tr>
<tr>
<td>Attic and Other</td>
<td>U-0.027</td>
<td>R-38.0</td>
<td>U-0.027</td>
</tr>
<tr>
<td><strong>Walls, Above-Grade</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>U-0.090</td>
<td>R-11.4 c.i.</td>
<td>U-0.080</td>
</tr>
<tr>
<td>Metal Building</td>
<td>U-0.113</td>
<td>R-13.0</td>
<td>U-0.057</td>
</tr>
<tr>
<td>Steel-Framed</td>
<td>U-0.064</td>
<td>R-13.0 + R-7.5 c.i.</td>
<td>U-0.064</td>
</tr>
<tr>
<td>Wood-Framed and Other</td>
<td>U-0.064</td>
<td>R-13.0 + R-3.8 c.i.</td>
<td>U-0.051</td>
</tr>
<tr>
<td><strong>Walls, Below-Grade</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below-Grade Wall</td>
<td>C-0.119</td>
<td>R-7.5 c.i.</td>
<td>C-0.119</td>
</tr>
<tr>
<td><strong>Floors</strong></td>
<td></td>
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<tr>
<td>Mass</td>
<td>U-0.074</td>
<td>R-10.4 c.i.</td>
<td>U-0.064</td>
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<tr>
<td>Steel-Joist</td>
<td>U-0.038</td>
<td>R-30.0</td>
<td>U-0.038</td>
</tr>
<tr>
<td>Wood-Framed and Other</td>
<td>U-0.033</td>
<td>R-30.0</td>
<td>U-0.033</td>
</tr>
<tr>
<td><strong>Slab-On-Grade Floors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unheated</td>
<td>F-0.730</td>
<td>NR</td>
<td>F-0.540</td>
</tr>
<tr>
<td>Heated</td>
<td>F-0.860</td>
<td>R-15 for 24 in.</td>
<td>F-0.860</td>
</tr>
<tr>
<td><strong>Opaque Doors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swinging</td>
<td>U-0.700</td>
<td>U-0.500</td>
<td>U-0.700</td>
</tr>
<tr>
<td>Nonswinging</td>
<td>U-0.500</td>
<td>U-0.500</td>
<td>U-1.450</td>
</tr>
<tr>
<td><strong>Fenestration</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Fenestration Assembly Max. U</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical Glazing, % of Wall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonmetal framing (all)</td>
<td>U-0.35</td>
<td>U-0.35</td>
<td>U-0.35</td>
</tr>
<tr>
<td>Metal framing (curtainwall/storefront)</td>
<td>SHGC-0.40 all</td>
<td>U-0.45</td>
<td>SHGC-0.40 all</td>
</tr>
<tr>
<td>Metal framing (entrance door)</td>
<td>U-0.80</td>
<td>U-0.80</td>
<td>U-0.80</td>
</tr>
<tr>
<td>Metal framing (all other)</td>
<td>U-0.55</td>
<td>U-0.55</td>
<td>U-1.20</td>
</tr>
</tbody>
</table>

Source: ASHRAE
Savings Opportunities

- **Exterior walls**
  - More insulation (R-13 + R7.5 c.i.)
  - Reduce air leakage

- **Roofs**
  - Cool roof
  - More Insulation (R-20 c.i.)

- **Windows**
  - Film or shading
  - Use double-layer windows

- **Exterior doors**
  - Reduce air leakage

- **Interior openings**
  - High speed rolling doors
  - Separate interior conditioned and unconditioned areas

Source: Rice Equipment
Homework

1. List the types of lights used in your facility
   1. **Bonus** – identify # of each type

2. Is your space conditioned (Y/N)?
   1. **If yes**, list top 2 types of equipment used?

3. Are there any openings in the building envelop or opportunities for quick doors?
   1. **If yes**, take a picture of the opportunity
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Type any questions or comments into the **Questions box**.
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Thr, Apr 23, 2020 | 1:00 - 3:00 PM ET

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Wed, Apr 29, 2020 | 1:00 - 3:00 PM ET

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General Inquiries gtw@retechadvisors.com

Program Support mschatz@retechadvisors.com

Tom Wenning
Oak Ridge National Lab
wenningtj@ornl.gov

Eli Levine
U.S. Department of Energy
eli.levine@ee.doe.gov
202-586-9929