**Thermal / Shade Curtains**

**What are Energy Curtains?**

- **Thermal curtains**
  - 80% of greenhouse heating at night
  - Reduces night heating up to 50%
  - Double poly w/ internal thermal blanket
    - 0.4 Btu/hr-F-ft² versus 0.7 Btu/hr-F-ft²
  - Double as summer shade system
- **Shade curtains**
  - Aluminized shades – 10°F lower air temperatures
  - Internal Shade cloth can be as thermal curtain
- Costs: $2 to $4.00 per sq. ft.
- Automated curtains for large greenhouses
- Manual open curtains for hoop houses - Lower cost?

**Disclaimer**

- Products mentioned in this presentation do not reflect an endorsement of that product.
- Likewise, a lack of mention does not imply that a product is not recommended.
- Photo Credit: Scott Sanford unless noted otherwise
Potential Energy Savings

Assumptions
- 30 x 120 gutter connected 6 bay greenhouse (21,600 sq.ft.)
- w/ std double poly film
- Propane cost - $1.50/ gallon
- Feb to June growing season, Madison, WI
- ~ $20,590 / year

Thermal curtain
- 100% roof covered – 52% energy savings
- ~ $ 13,435 / year
- Savings - $7155 / year (35%)

Potential Energy Savings

Assumptions
- 30 x 96 free standing greenhouse
- w/ std double poly film
- Propane cost - $1.50/ gallon
- Feb to June growing season, Madison, WI
- ~ $3120 / year

Thermal curtain
- 90% roof covered & 50% gable ends – 52% energy savings
- ~ $ 2130 / year
- Savings - $ 1000 / year (32%)

Types of Curtain Systems

- Gutter to Gutter
  - Curtain at bottom of truss
  - Reduces volume of air to be heated
  - Lower cost installation

Issues with curtain installations?
Curtain Installation Issues

- Plants hanging from rafters
- Irrigation hanging from rafters
- LOTS of Things hanging from rafters
- Heating pipes
- Poly tubes
- Heaters – Location & heat distribution

- Gable or roof vents or open roof systems
  - Fully drawn curtain will restrict summer air flow
  - Use porous curtain material

Types of Curtain Systems

Truss to Truss

- Follows roof profile part way
- Allow curtain to be installed without moving equipment

Thermal / Shade Screen
Thermal / Shade Materials

- Non-porous material
  - Highest heat retention
  - Impervious to water and air movement
  - Can fail if water collects on top of curtain
- Semi-porous materials (preferred)
  - Allows moisture to migrate
  - High heat retention – 50 to 75%
  - Porous curtains
    - Allows condensate and rain leakage to drain
    - Lower heat retention than nonporous materials – 20 to 30%
- Shade in summer / heat retention
  - Higher shading factor = Higher heat retention
- Curtain life: 8 to 12 years

Curtain Materials – Semi porous

Aluminized and clear polyethylene woven fabric

<table>
<thead>
<tr>
<th>Type of Screen</th>
<th>Ave Light Transmission(%)</th>
<th>Energy Savings at night (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-Porous fabrics</td>
<td>Shade/energy-saving</td>
<td></td>
</tr>
<tr>
<td>XLS 14</td>
<td>55</td>
<td>52</td>
</tr>
<tr>
<td>XLS 15</td>
<td>45</td>
<td>57</td>
</tr>
<tr>
<td>XLS 16</td>
<td>35</td>
<td>62</td>
</tr>
<tr>
<td>XLS 17</td>
<td>25</td>
<td>67</td>
</tr>
<tr>
<td>XLS Obscura</td>
<td>&lt; 0.1</td>
<td>75</td>
</tr>
<tr>
<td>Porous Construction -</td>
<td>Shading / Ventilation</td>
<td></td>
</tr>
<tr>
<td>XLS 14 F</td>
<td>58</td>
<td>20</td>
</tr>
<tr>
<td>XLS 15 F</td>
<td>49</td>
<td>20</td>
</tr>
<tr>
<td>XLS 16 F</td>
<td>38</td>
<td>25</td>
</tr>
<tr>
<td>XLS 17 F</td>
<td>27</td>
<td>30</td>
</tr>
<tr>
<td>Aluminet R -50%</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>Aluminet R -70%</td>
<td>30</td>
<td>50</td>
</tr>
</tbody>
</table>

Which shade factor to choose?

- Heat of summer maximum sunlight (June, July)
  - 10,000 foot-candles
- Most bedding and flowering plants can tolerate 4000 to 5000 foot-candles of light
- Greenhouse glazing light transmission
  - Glass ~ 90%
  - Double Poly ~ 80%
- 10,000 fc x 80% x 55% LT = 4400 foot-candles
  - 45% shading/ 55% light transmission recommended (52% energy savings)
Other Material parameters

- Flammability
- Roll up, bunch or folding
- Day length control (blackout)

Curtain Support Systems

- Slide on cables
  - Monofilament line
- Suspended from cables
  - Monofilament line
  - Stainless Steel cables

Opening Devices

- Motorized
  - Automated opening and closing
- Hand Crank
  - Reduced cost
  - Daily Task
- Hand Pull
  - Low cost for hobby greenhouses
  - Grasp leading edge and pull/push

Motorized Curtain Opening Cable Drive
Motorized Curtain Opening
Push Rod Type
1) Motor & gearbox
2) Drive shaft
3) Rack and Pinion
4) Push rod
5) Attachment to leading edge

Hand Crank Opening Device
• Cable wrapped around shaft
• Cable “walks” along shaft
• Pulleys loop cable
  • Use Steel pulleys

Cable Winch Drive
• Spool on / spool off
  • Cable wraps equal curtain travel distance
  • End of cable clamped to drive shaft
  • Cable wrapping up on one side of the spool and unwrapping on other side
  • Larger diameter shaft equals smaller translational distance

Attaching curtain to opener
**Edge Seals**

- “Air tight” from convection / infiltration

**Support lines and cables**

- Additional purlin
  - Anchor for support lines
  - Anchor for drive cables
- Sliding curtain
  - Monofilament line
  - Spacing 12-16 inches
- Suspended Curtain
  - Stainless steel cable
  - Spacing 18 to 48”

**Edge Seals**

- Weighed edge lays on top of curtain
Corners – End of Gutter

- "Plug" the end of the gutter
- Staple a piece of cloth in end of gutter
- Ensure curtain seal

Sealing Truss Sections

Leading Edge Seal

Leading Edge Seal

- Greenhouse Rafter
- Leading edge
- Curtain
- Curtain Support line
- Leading Edge Seal
Controllers

Curtain Management
- Maintain seals
- Leaks – chill plants under leak
- Opening
  - Allow air above curtain to warm up before opening
  - Open in stages
  - Condensation / Ice
- Leave open to melt snow

Curtain System Costs
- Typical - $2 - $4 per square foot
- Variables –
  - Size
  - Type of screen material
  - Number of obstructions
- Easiest to install in
  - Gutter connected greenhouse
  - A-Frame greenhouse

Manual Curtain Project
- Use off-the-self components
- Make in a shop with vise, welder, drill press
Support for Hanging Things

Grower Installed Curtain

Curtain System Cost

- Freestanding Gothic greenhouse - 30 x 96
  - Commercial curtain - ~ $7500 materials
    - Truss to Truss / Slope - Slope
    - Covers ~ 100% of roof area

- Manual Curtain System
  - Covers bottom cord of truss – about 60% of roof
  - ~ $3500 materials (cover bottom of truss – 23 ft)
  - ~ $2000 for roll-up sides for 100 % roof coverage
  - ~ $5500 total

Curtain System Suppliers

- VRE Systems
  - www.vresystems.com

- Wadsworth Control Systems
  - www.wadsworthcontrols.com

- Gintec Shade Technologies
  - www.gintec-shade.com

Shade/Thermal Curtain Material

- Ludvig Svensson – www.svenssonamericas.com

- TGU Products – Fiberfil Screen
  - Distributed by United Greenhouse Systems, Edgerton, WI
  - www.unitedgreenhouse.com
Emerging Technologies

- SunArc –
  - Injects foam between double poly films
  - 50% energy savings claim
  - Foam dissipates by itself
  - Reside washed away after sun-up
  - [www.sunarc.ca/english/insulation.html](http://www.sunarc.ca/english/insulation.html)

Foam bubbles

Source: [http://www.tdc.ca/bubbleinsulation.jpg](http://www.tdc.ca/bubbleinsulation.jpg)

State/Utility Energy Grants

- Database of State Incentives for Renewables and Efficiency (DSIRE)
  - [www.dsireusa.org](http://www.dsireusa.org)
  - Grants by state
    - By Renewable Energy or Energy Efficiency
    - By Utility
    - By Residential, business, renewables
  - Federal Grants

Video:
**Wisconsin Energy Grants**

- Wisconsin Focus on Energy
  - Grants for energy efficiency & renewable energy
  - Grants up to 25% of project cost
- Utility must be participating
  - Agricultural program provides free audits
  - Unbiased advise (don’t sell equipment)
  - Provide estimated energy & cost savings
- www.focusonenergy.com
- 1-800-762-7077

**Rural Energy for America Program (REAP)**

- Part of 2008 farm bill -
- Project Types
  - Renewable Energy
  - Energy Efficiency
  - Feasibility Study
- Grants
  - Cover up to 25% of project costs
    - $ 10,000 project = $2500 max grant
  - Grant Minimum / Maximum
    - Renewable energy -$2500 / $500,000
    - Energy Efficiency - $1500 / $250,000
  - Not for transportation or field equipment
  - Competitive grant process

**Questions?**

This presentation was developed for SARE by Scott Sanford
Senior Outreach Specialist
Rural Energy Program
University of Wisconsin – Madison
sasanford@wisc.edu