Solar Crop Drying

Efficient, Simple, Cost Effective and Building Integrated

Presented by:
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Conserval Systems Inc.

Project funding provided by:
The California Air Resources Board
ICAT (Innovative Clean Air Technology Program)
Web Cast Viewers

Please email your questions and comments to:
onair@arb.ca.gov
Solar Crop Drying Topics

- ICAT
- What is a transpired solar collector?
- How solar crop drying works
- System details/design
- Demonstration Projects
- Environmental benefits
- Economics of solar crop drying
- IEA
- Future solar crop drying potential
- Concluding remarks
Innovative Clean Air Technology Program (ICAT)

“ICAT funds technically solid projects that can demonstrate the commercial utility in California of technical innovations that will improve emission prevention and control.”

– California Air Resources Board
Transpired solar collector

After years of R & D, it was found that a single, non-glazed perforated panel was more efficient and less expensive.

“The transpired solar collector is a thin sheet of dark perforated metal. The dark wall absorbs solar radiation and heats fresh air drawn through its perforations by a building's ventilation fans.” — National Renewable Energy Laboratory (NREL)
Panel Properties

- Panels can be specified as aluminum or steel
- Wide variety of standard colors available
- Over 240 perforations per ft$^2$
- Corrugated to increase structural rigidity
Crop Drying Basics

• Drying requires air movement and heat
• Warm air absorbs more moisture than cold air
• Increasing air flow or heat reduces drying time
• Fossil fuels generally provide heat source
How Solar Crop Drying Works

- Sun shines on the solar collector
- Air is drawn through tiny perforations
- Heated air is drawn to the top of the system and into the dryer via the dryer fan

The following animation will help to explain the concept:
Main components of a solar crop drying system

- **Solarwall Panel**
- **Air Space**
- **Crop Dryer**
- **Material to be Dried**
- **Fan/Burner**
- **Dryer Fan/Burner**
The Solarwall panel absorbs the sun’s energy.
The boundary layer air is heated and drawn through tiny perforations into the air space.
The boundary layer air is heated and drawn through tiny perforations into the air space.
The heated air travels up to the air intake and is drawn into the dryer.
Additional heat is provided by the burner (if required) and the air passes through the material being dried.
Heat loss through the roof is recovered when the fan is running.
Solar Drying

- Dries all types of produce
- Excellent for tea, coffee, fruit, spices, rubber, cocoa beans, rice, timber, nuts and manure
- Suitable for laundry drying & other commercial products
- Works with tunnel, trough, conveyor and other types of driers
Typical Installation

- Panels are installed 6 – 12 inches from roof
- Can be installed over or around existing roof openings
- Can be installed over any non-combustible, waterproof roof membrane
- Easy installation – no special skills or tools needed
Temperature Rise Graph

Air Temperature Rise vs. Solar Radiation for Various Air Flow Rates

Solar Radiation - BTU/ft² of Transpired Collector

Air Temperature Rise vs. Solar Radiation for Various Air Flow Rates

Solar Radiation - Watt/m² of Transpired Collector

- **Red Line**: 1.1 CFM/ft² (20 m³/h/m²)
- **Blue Line**: 4.0 CFM/ft² (73 m³/h/m²)
- **Green Line**: 7.0 CFM/ft² (130 m³/h/m²)
Demonstration Projects

With generous support from the California Air Resources Board, five solar crop drying systems were installed in California:

- **Sunsweet** (prunes)
- **Carriere & Sons** (walnuts)
- **Keyawa Orchards** (walnuts)
- **Korina Farms** (pecans)
- **Sonoma County Herb Exchange** (various herbs)
Sunsweet (prunes)

Prune Dryer Layout

- 6' Diameter Fan, 50,000 CFM at 1" Static Pressure
- 35 Horsepower Motor
- 3 Million BTU/hr Burner
- From Solarwall Cavity
- 190°
- 160°
- Baffles
- DRY FRUIT
- GREEN FRUIT

FROM SOLARWALL CAVITY

Prune Dryer Layout
Sunsweet (prunes)

Fan Intake and Bypass
Gas Usage (% Difference) vs. Date
Sunsweet - 2004 Solarwall Monitoring

Average Solarwall Gas Savings: 8.7%
<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Ambient Temp. (°F)</th>
<th>Solarwall Temp. (°F)</th>
<th>Temp. Rise</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/12/04</td>
<td>13:30</td>
<td>109.4</td>
<td>129.4</td>
<td>20.0</td>
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<tr>
<td>08/13/04</td>
<td>15:30</td>
<td>104.3</td>
<td>126.6</td>
<td>22.3</td>
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<td>127.4</td>
<td>31.0</td>
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<td>99.8</td>
<td>24.1</td>
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<tr>
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<td>121.6</td>
<td>22.7</td>
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<td>80.4</td>
<td>127.6</td>
<td>47.2</td>
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<tr>
<td>SOLARWALL Size</td>
<td>1,225 ft²</td>
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<td>----------------------</td>
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<tr>
<td>Air Volume Preheated</td>
<td>10,000 cfm (of estimated 50,000 cfm)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Projected Savings</td>
<td>100 MMBTU (per month of use)</td>
<td></td>
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<tr>
<td>Maximum Air Temperature</td>
<td>185° F</td>
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</tbody>
</table>
Carriere & Sons (walnuts)

Roof-Mounted Solarwall Panels
Carriere & Sons (walnuts)

Fan Intake
Carriere & Sons (walnuts)

Walnut Dryer Layout

Solar Wall Panels:
- Fresh air enters solar panels.
- Air is heated and enters the fan inlet.
- Warm air is directed towards the walnuts.
- Solar duct covers 1/3 of the fan opening.
- Fresh air door mostly closed.
<table>
<thead>
<tr>
<th>SOLARWALL Size</th>
<th>3,200 ft²</th>
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</thead>
<tbody>
<tr>
<td>Air Volume Preheated</td>
<td>17,500 cfm (of estimated 70,000 cfm)</td>
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<tr>
<td>Projected Savings</td>
<td>172 MMBTU (per month of use)</td>
</tr>
<tr>
<td>Maximum Air Temperature</td>
<td>110° F</td>
</tr>
</tbody>
</table>
Keyawa Orchards (walnuts)

Roof-Mounted Solarwall Panels
Keyawa Orchards (walnuts)

Fan Supply Ducts
Air Temperature vs. Time
Keyawa Orchards - 2004 Solarwall Monitoring

- Ambient Air
- Solar Heated Air
<table>
<thead>
<tr>
<th>SOLARWALL Size</th>
<th>9,300 ft²</th>
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</thead>
<tbody>
<tr>
<td>Air Volume Preheated</td>
<td>65,000 cfm</td>
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<tr>
<td>Projected Savings</td>
<td>572 MMBTU (per month of use)</td>
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<tr>
<td>Maximum Air Temperature</td>
<td>110° F</td>
</tr>
</tbody>
</table>
Korina Farms (pecans)

Roof-Mounted Solarwall Panels
Korina Farms (pecans)

Fan Supply Duct (bypass open)
Korina Farms (pecans)

General Layout
Air Temperature vs. Time
Korina Farms - 2004 Solarwall Monitoring

- **Ambient Air**
- **Solar Heated Air**
<table>
<thead>
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<th>SOLARWALL Size</th>
<th>5,200 ft²</th>
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<tbody>
<tr>
<td>Air Volume Preheated</td>
<td>37,000 cfm</td>
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<tr>
<td>Projected Savings</td>
<td>163 MMBTU</td>
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<td></td>
<td>(per month of use)</td>
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<tr>
<td>Maximum Air</td>
<td>80° F</td>
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<tr>
<td>Temperature</td>
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</table>
Sonoma County Herb Exchange (various herbs)

Roof-Mounted Solarwall Panels
Sonoma County Herb Exchange (various herbs)

Solar Batch Dryer
Sonoma County Herb Exchange (various herbs)

Air Temperature vs. Time
Sonoma County Herb Exchange - 2005 Solarwall Monitoring

Air Temperature (°F)

- Ambient Air
- Solar Heated Air

Time

8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00
<table>
<thead>
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<th>SOLARWALL Size</th>
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<td>Air Volume Preheated</td>
<td>350 cfm</td>
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<td>Projected Savings</td>
<td>3 MMBTU</td>
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<tr>
<td></td>
<td>(per month of use)</td>
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<tr>
<td>Maximum Air Temperature</td>
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</tbody>
</table>
## ICAT Summary

### Total Projected Savings (per month): 1,010 MMBTU

### Total Cumulative Savings (per year): 1,950 MMBTU

<table>
<thead>
<tr>
<th>SOLARWALL Size</th>
<th>Prunes</th>
<th>Walnuts</th>
<th>Walnuts</th>
<th>Pecans</th>
<th>Herbs</th>
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<tbody>
<tr>
<td>Sunsweet</td>
<td>1,225 ft²</td>
<td>3,200 ft²</td>
<td>9,300 ft²</td>
<td>5,200 ft²</td>
<td>105 ft²</td>
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<td>Carriere</td>
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### Projected Savings (per month)

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<th>SOLARWALL Size</th>
<th>100 MMBTU</th>
<th>172 MMBTU</th>
<th>572 MMBTU</th>
<th>163 MMBTU</th>
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### Months of Use per Year

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Solar Air Heating: The Right Choice for Agriculture

- Fuel is renewable and non-polluting
- Maintenance-free
- Lifetime of free heating
- Cost effective
- Government incentives available
- Socially responsible
- New business opportunities
IEA Task 29 states – “One of the most promising applications for active solar heating worldwide is the drying of agricultural products.”
3 Key Barriers:

- Lack of awareness
- Lack of good technical information
- Lack of good practical experience
Café Duran – Panama

Coffee Drying
Coopeldos – Costa Rica

Solar Displaces Wood Fuel
Drying Coir Pith – India
Chicken Barns – Quebec

Poulailler

Longueur: 300’
Hauteur: 10’3”
Surface nette: 3000’
Mise en opération: 2003
Manure Drying – Quebec

Drying Chicken Manure
Kreher’s – Buffalo, NY

Drying Chicken Manure
NASA – Edwards, CA

Ventilation Air Preheater
PV Thermal – Petaluma, CA
Summary

- Five solar dryers successfully installed
- High value crops provided initial market
- Significant day time solar energy savings realized
- USDA and other agricultural agencies need to disseminate solar drying information
- ICAT demonstration assistance vital to the success of this project
For more information on solar air heating, please contact:

Conserval Engineering, Inc
www.solarwall.com
Email: jhollick@solarwall.com

The California Air Resources Board
www.arb.ca.gov
Email: schurch@arb.ca.gov

International Energy Agency (task 29)
www.iea-shc.org/task29/
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