



# 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](mailto: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

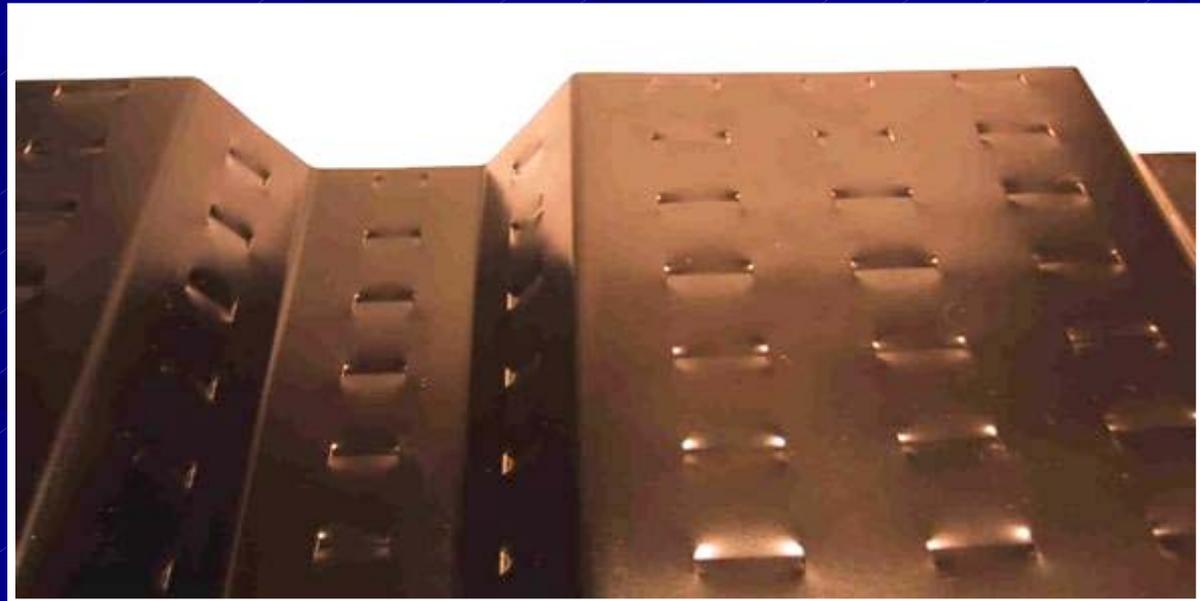
After years of R & D, it was found that a single, non-glazed perforated panel was more efficient and less expensive

“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<sup>2</sup>
- Corrugated to increase structural rigidity





# Crop Drying Basics

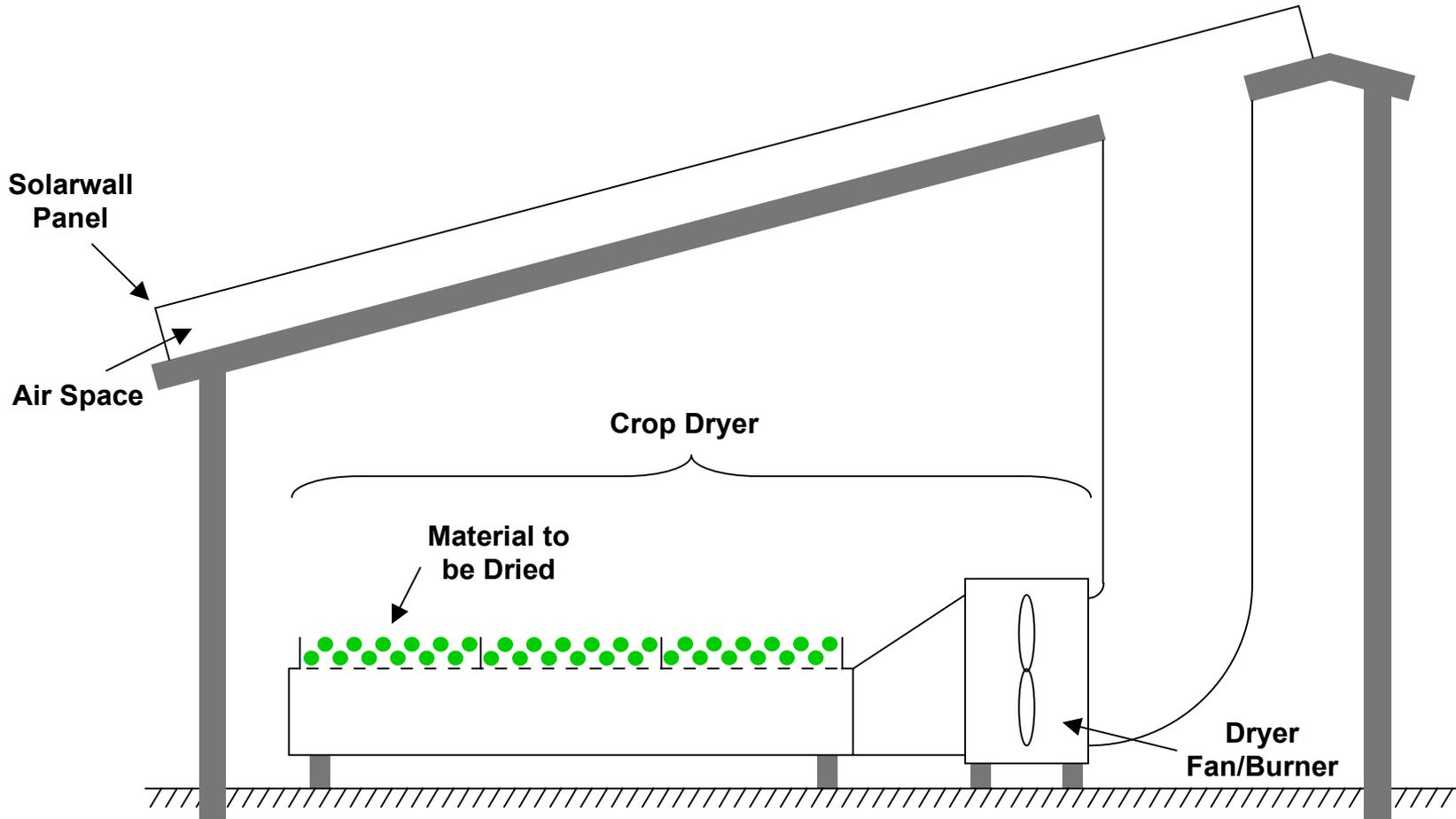
- Drying requires air movement and heat
- Warm air absorbs more moisture than cold air
- Increasing air flow or heat reduces drying time
- Fossil fuels generally provide heat source



# 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:

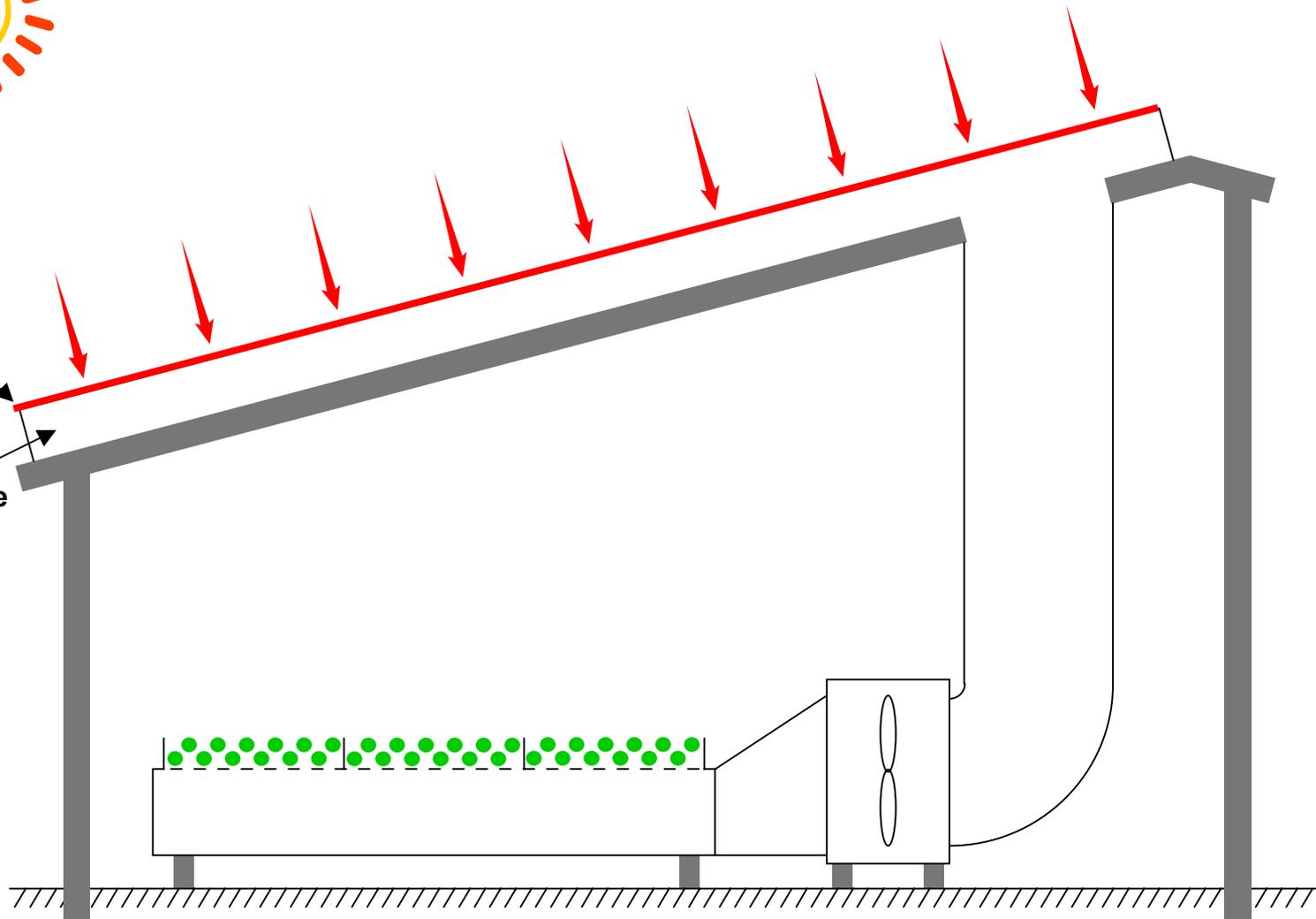


Main components of a solar crop drying system

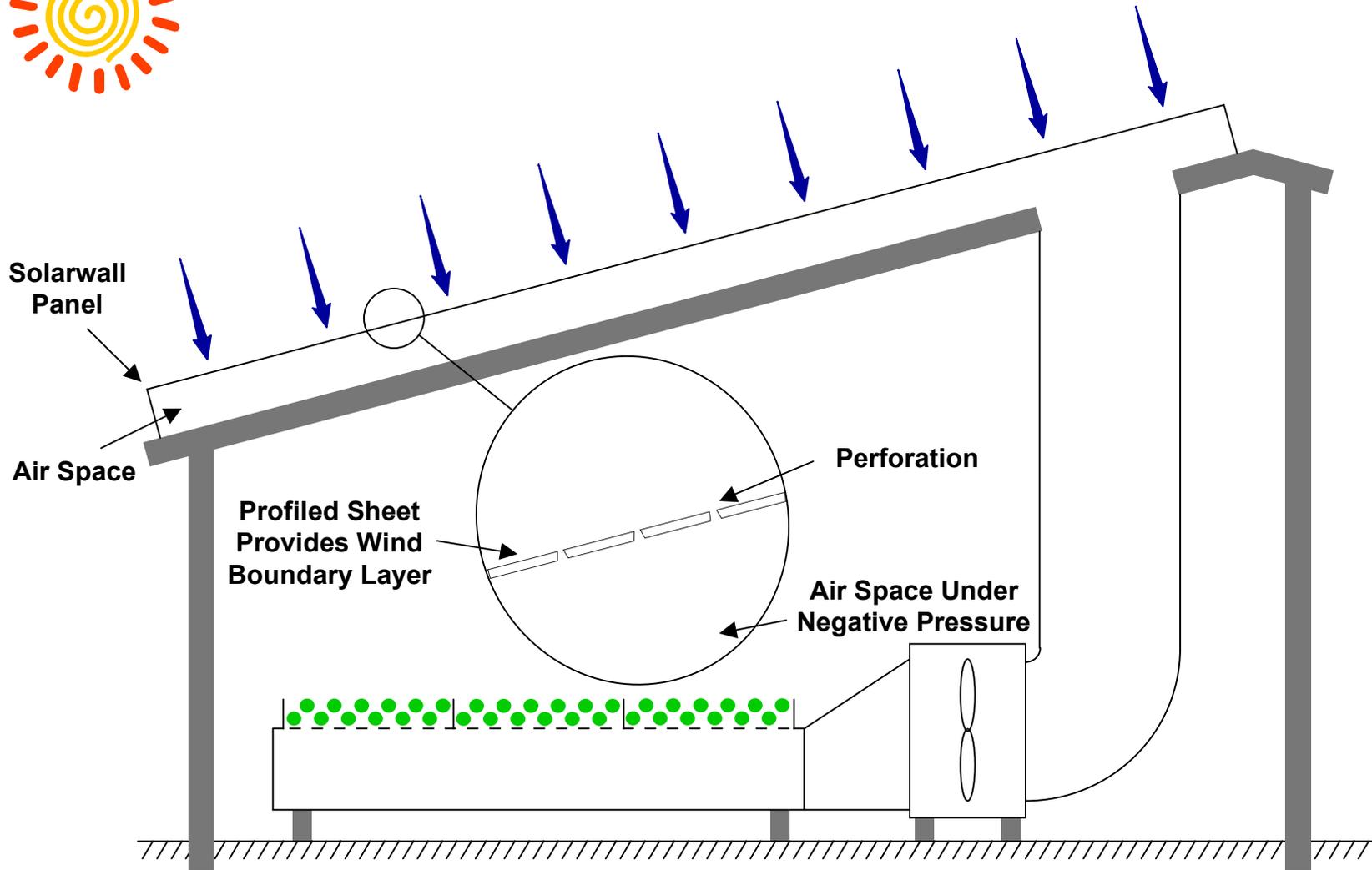


Solarwall  
Panel

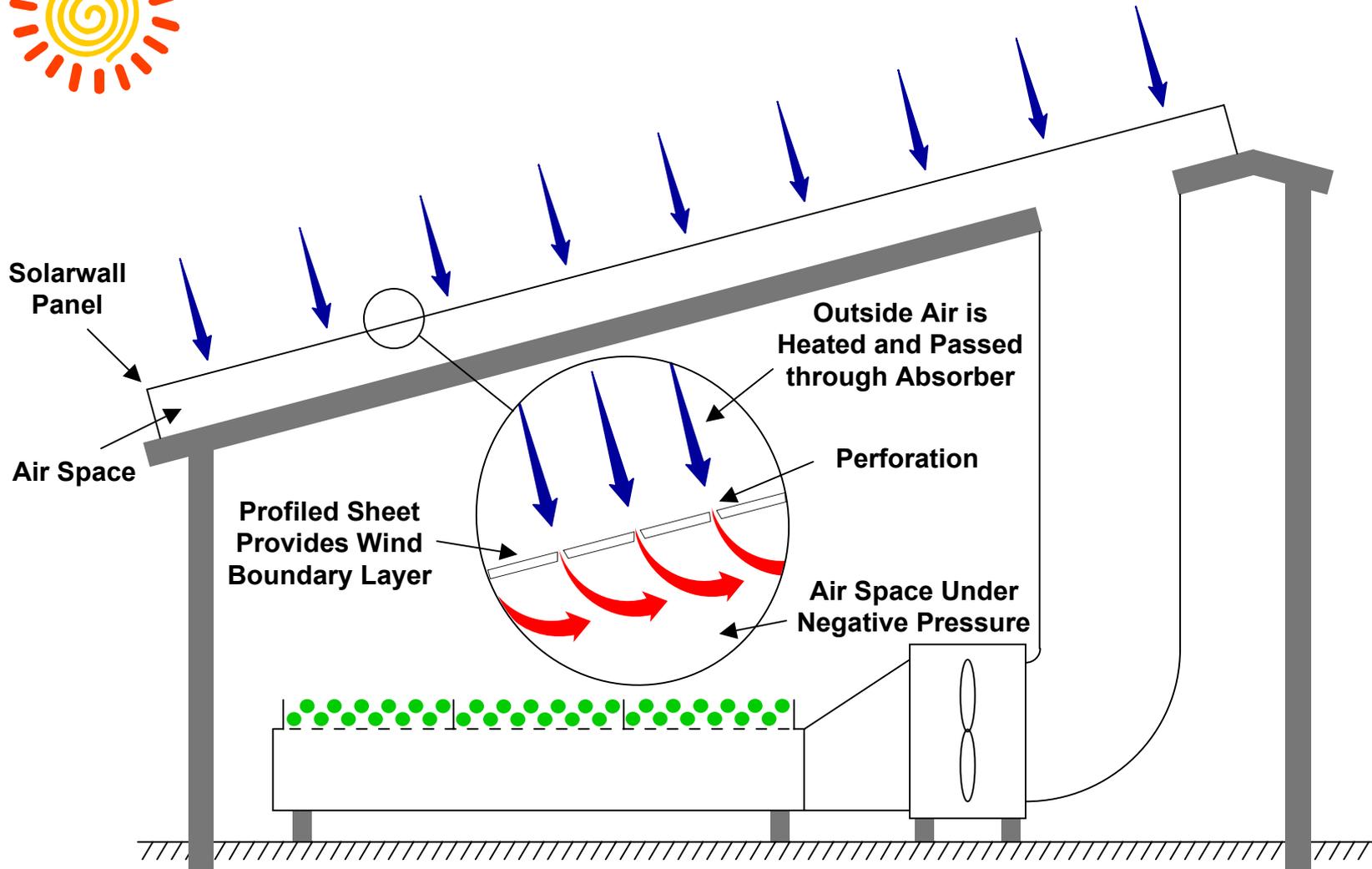
Air Space



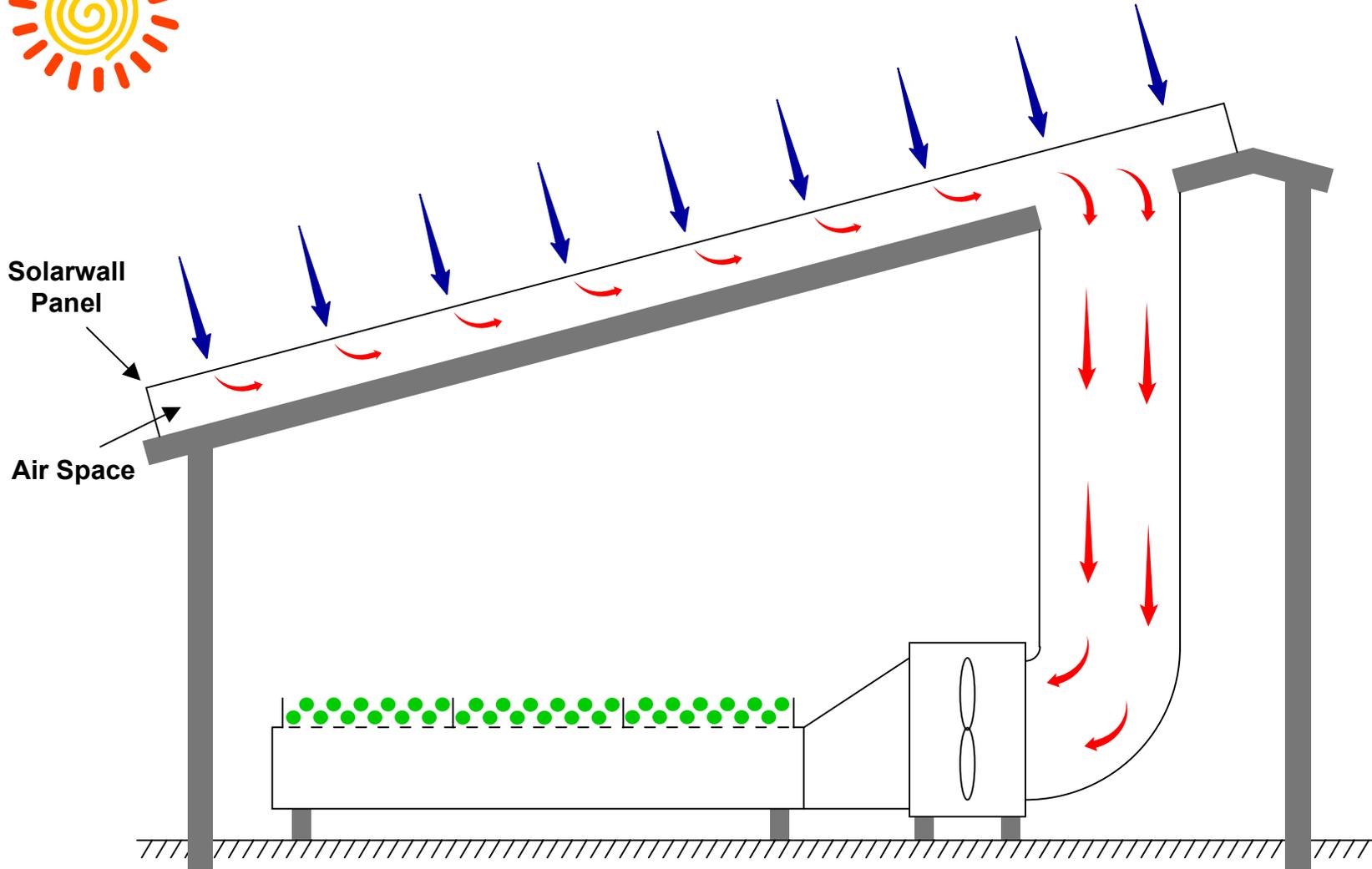
The Solarwall panel absorbs the sun's energy



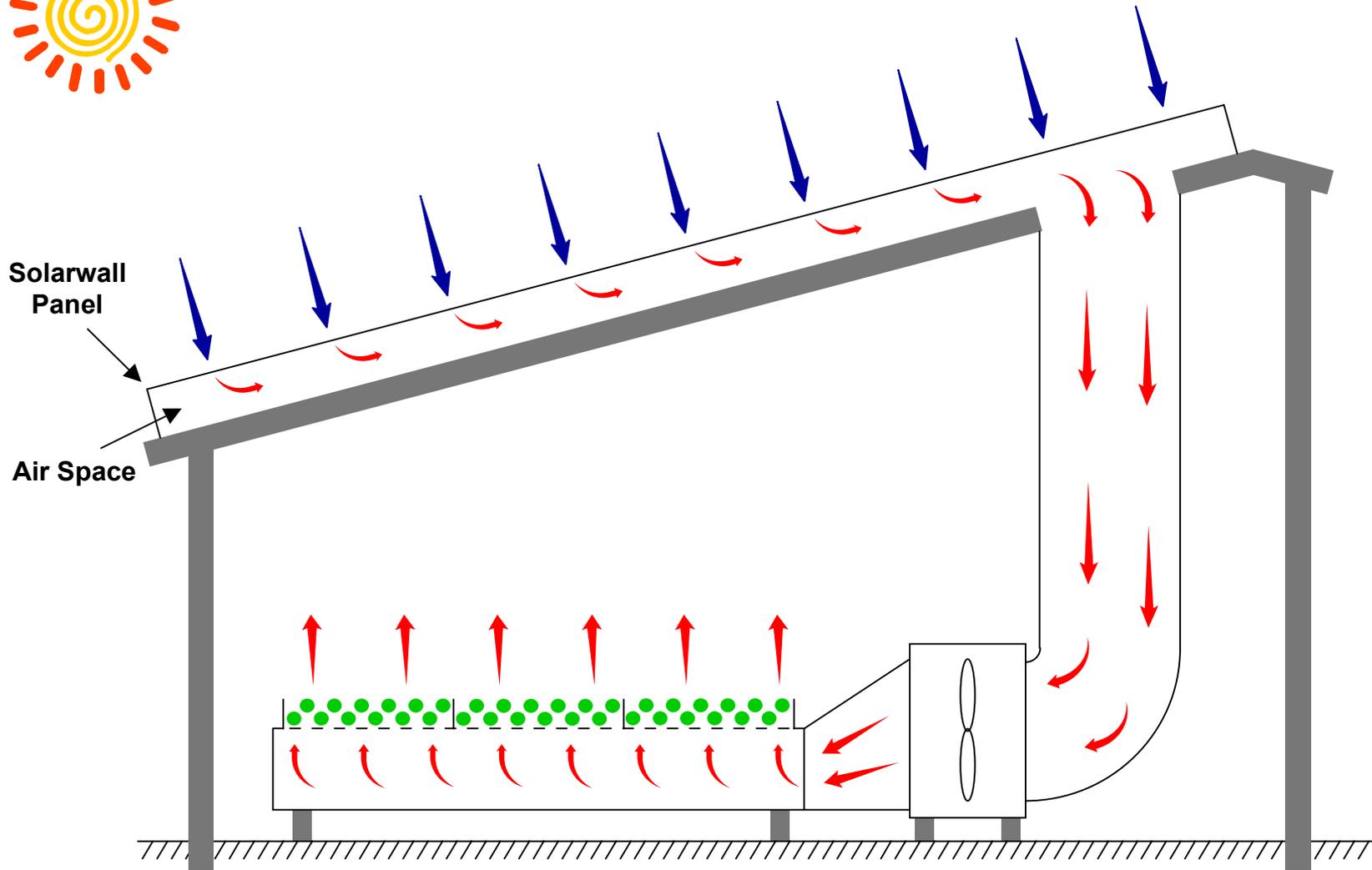
The boundary layer air is heated and drawn through tiny perforations into the air space



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

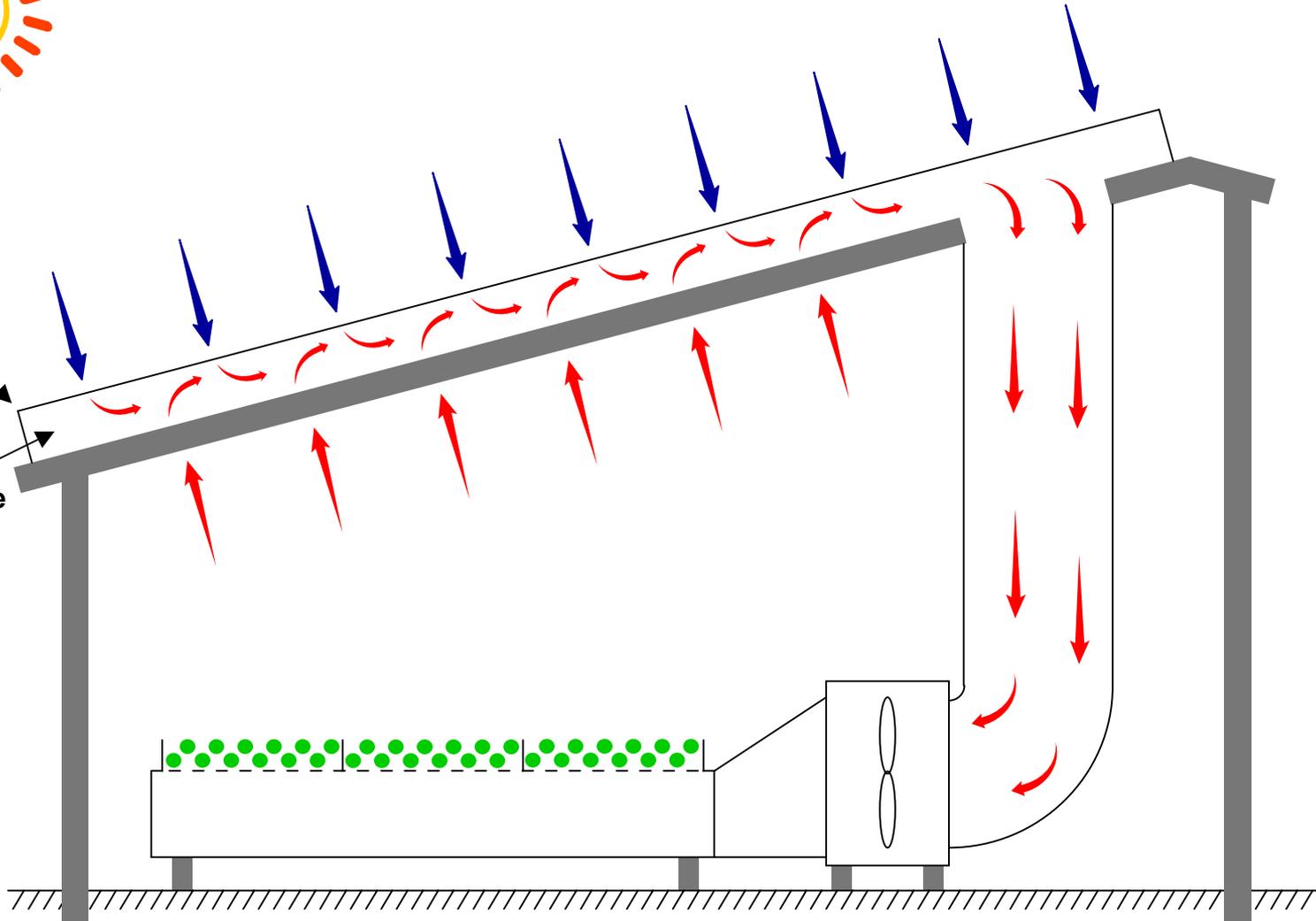


Additional heat is provided by the burner (if required) and the air passes through the material being dried



Solarwall  
Panel

Air Space



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

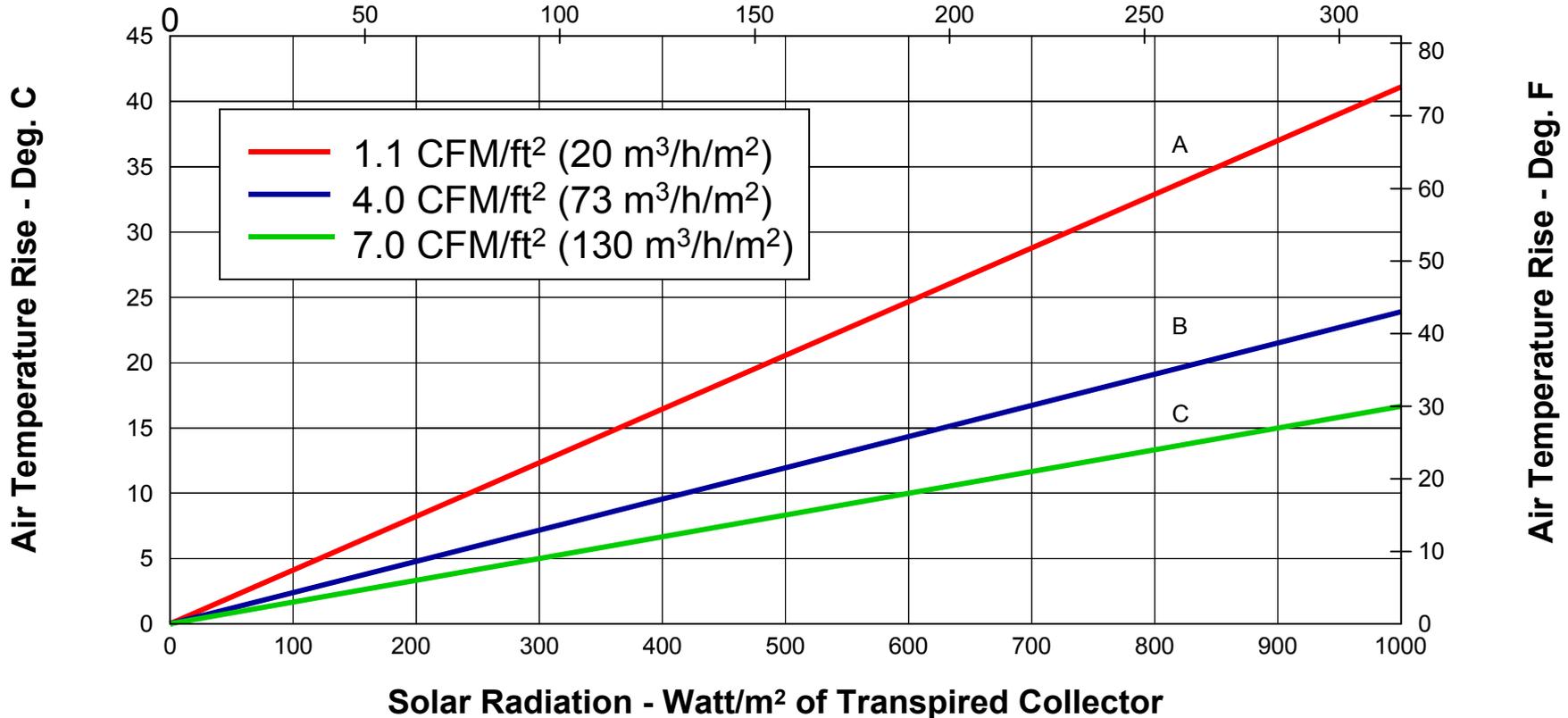




# Temperature Rise Graph

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

Solar Radiation - BTU/ft<sup>2</sup> of Transpired Collector





# 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)



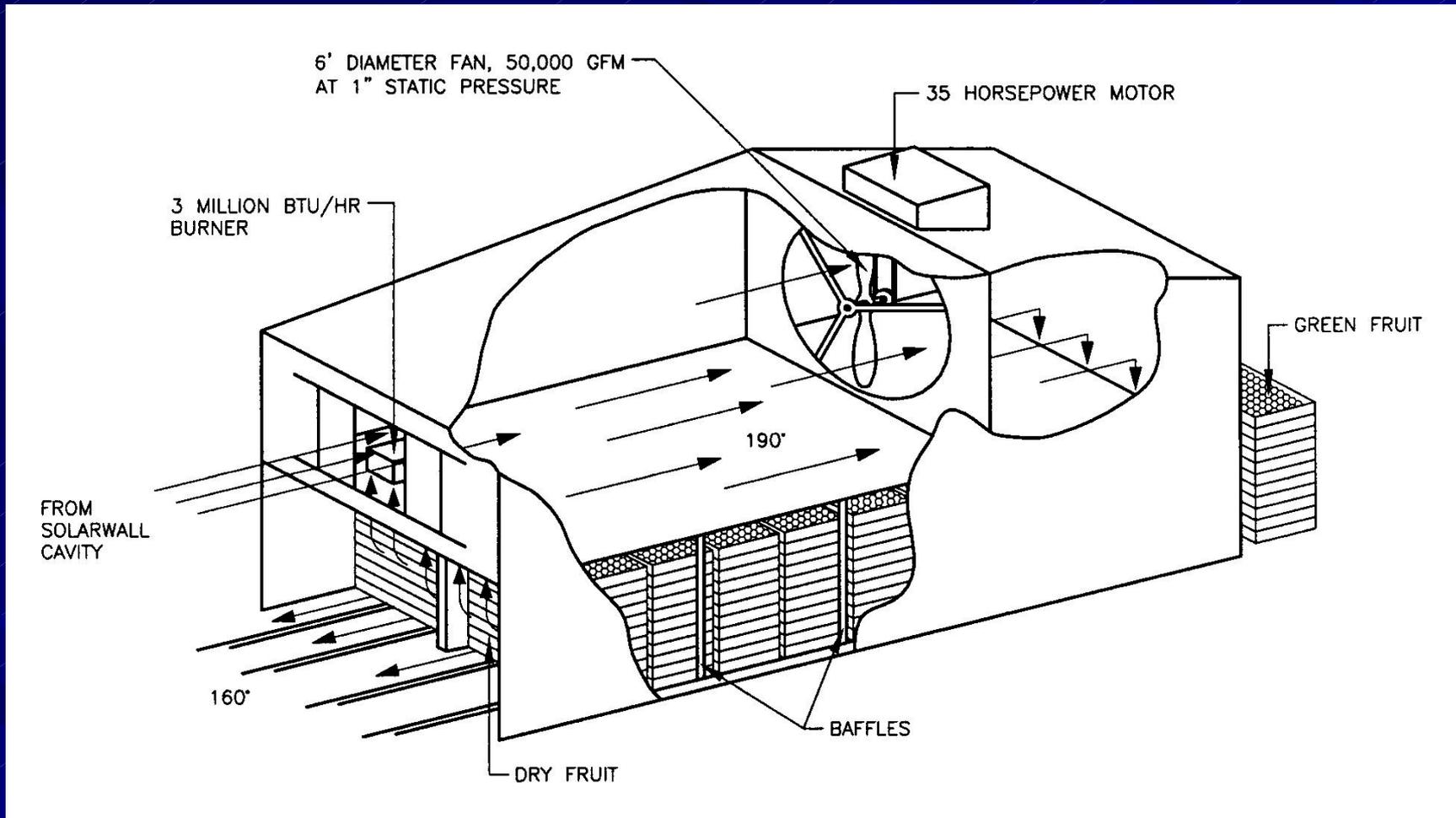
Sunsweet (prunes)



Roof-Mounted Solarwall Panels



# Sunsweet (prunes)



Prune Dryer Layout



# Sunsweet (prunes)



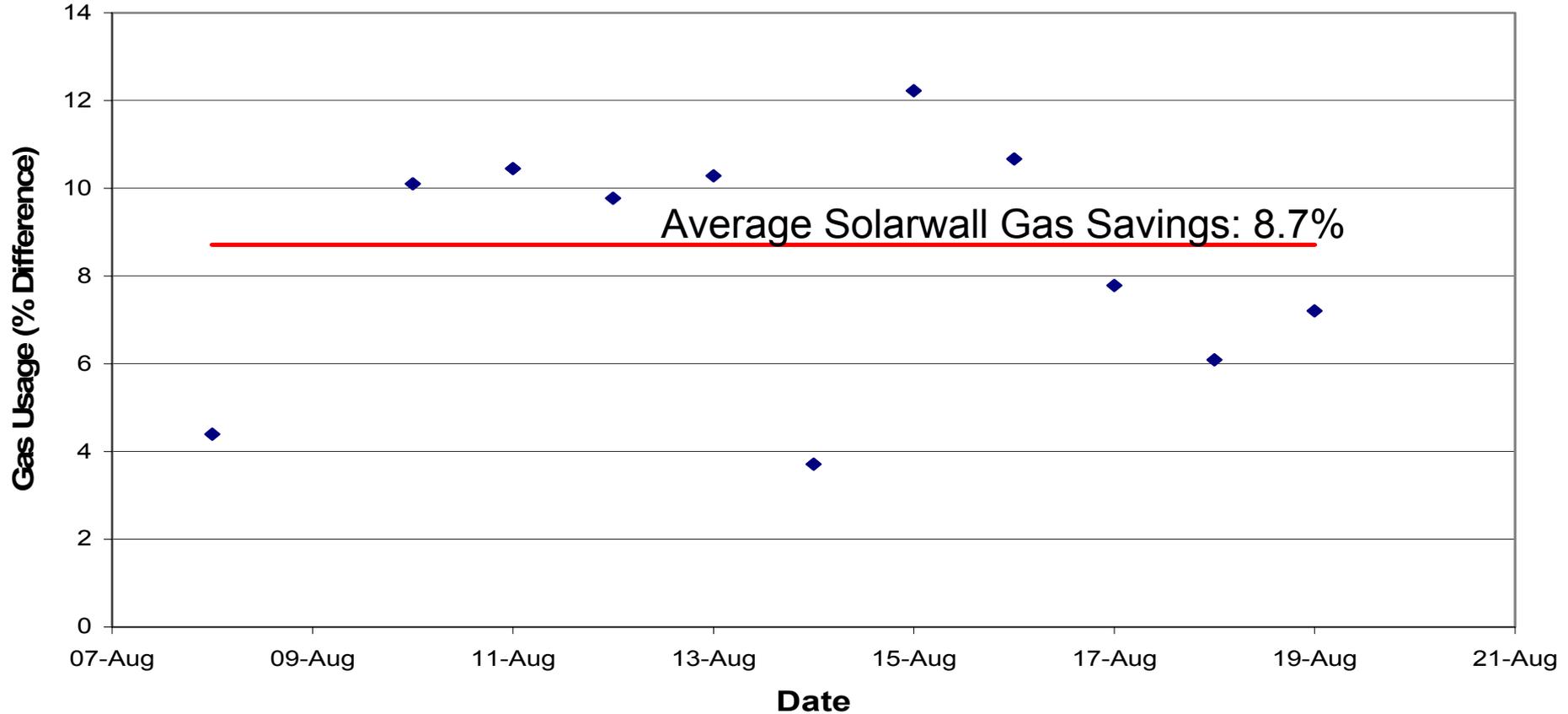
Fan Intake and Bypass



# Sunsweet (prunes)

## Gas Usage (% Difference) vs. Date

Sunsweet - 2004 Solarwall Monitoring





# Sunsweet (prunes)

Date	Time	Ambient Temp. (°F)	Solarwall Temp. (°F)	Temp. Rise
08/12/04	13:30	109.4	129.4	20.0
08/13/04	15:30	104.3	126.6	22.3
08/14/04	13:00	96.4	127.4	31.0
08/15/04	7:15	75.7	99.8	24.1
08/15/04	8:15	98.9	121.6	22.7
08/16/04	11:15	80.4	127.6	47.2



# Sunsweet (prunes)

SOLARWALL Size	1,225 ft <sup>2</sup>
Air Volume Preheated	10,000 cfm (of estimated 50,000 cfm)
Projected Savings	100 MMBTU (per month of use)
Maximum Air Temperature	185° F



# Carriere & Sons (walnuts)



Roof-Mounted Solarwall Panels



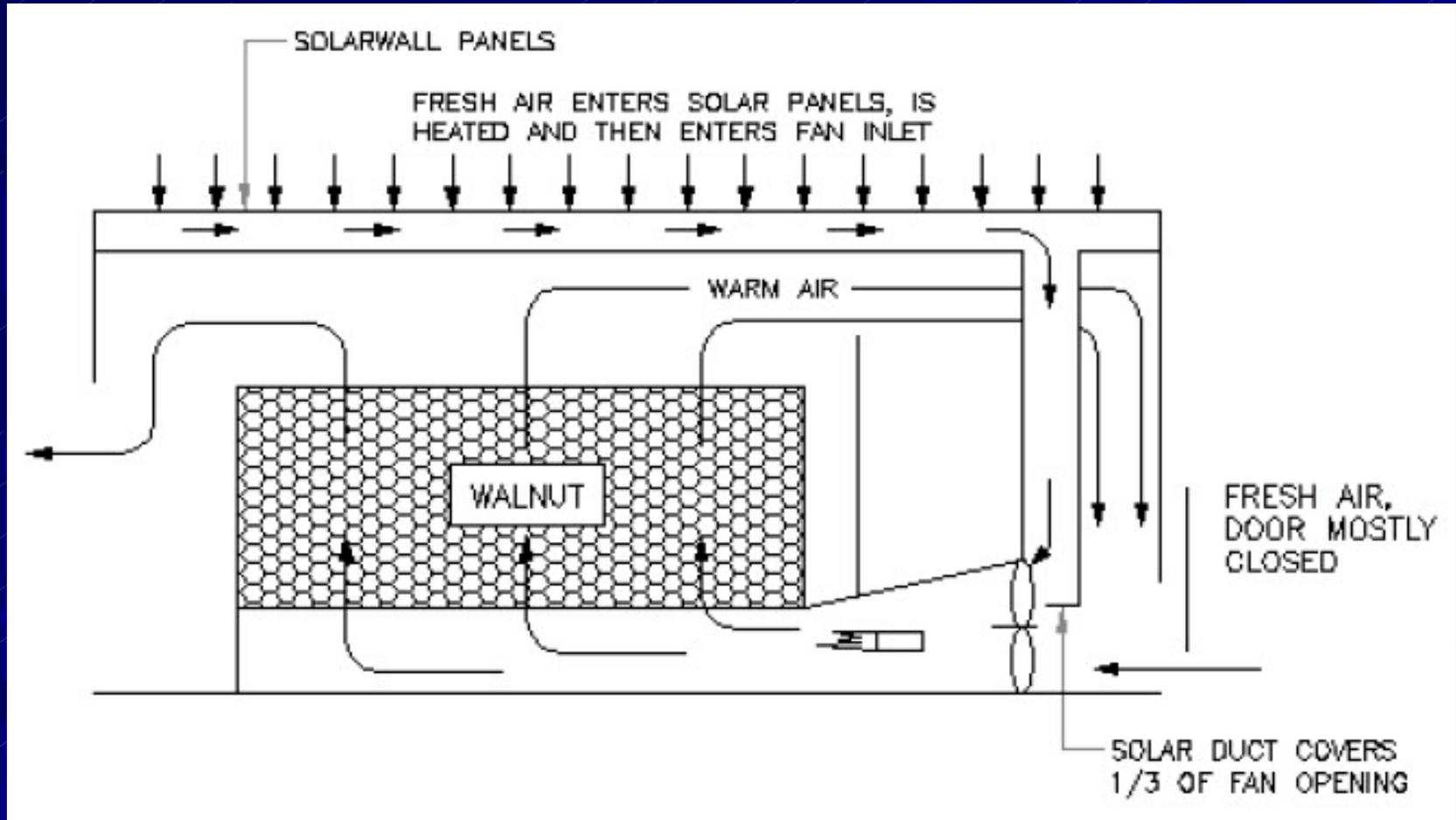
# Carriere & Sons (walnuts)



Fan Intake



# Carriere & Sons (walnuts)



Walnut Dryer Layout



# Carriere & Sons (walnuts)

SOLARWALL Size	3,200 ft <sup>2</sup>
Air Volume Preheated	17,500 cfm (of estimated 70,000 cfm)
Projected Savings	172 MMBTU (per month of use)
Maximum Air Temperature	110° F



# Keyawa Orchards (walnuts)



Roof-Mounted Solarwall Panels



# Keyawa Orchards (walnuts)



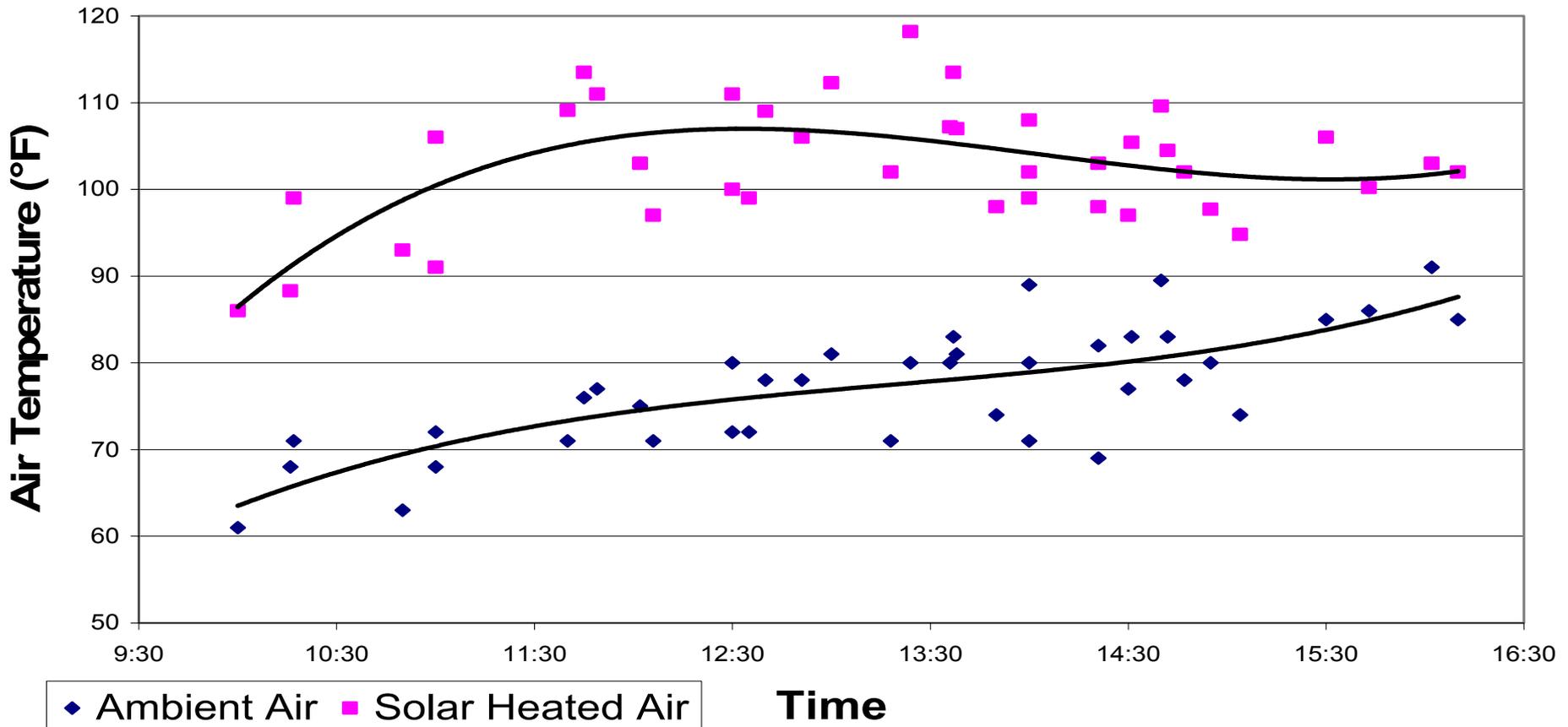
Fan Supply Ducts



# Keyawa Orchards (walnuts)

## Air Temperature vs. Time

Keyawa Orchards - 2004 Solarwall Monitoring





# Keyawa Orchards (walnuts)

SOLARWALL Size	9,300 ft <sup>2</sup>
Air Volume Preheated	65,000 cfm
Projected Savings	572 MMBTU (per month of use)
Maximum Air Temperature	110° F



# Korina Farms (pecans)



Roof-Mounted Solarwall Panels



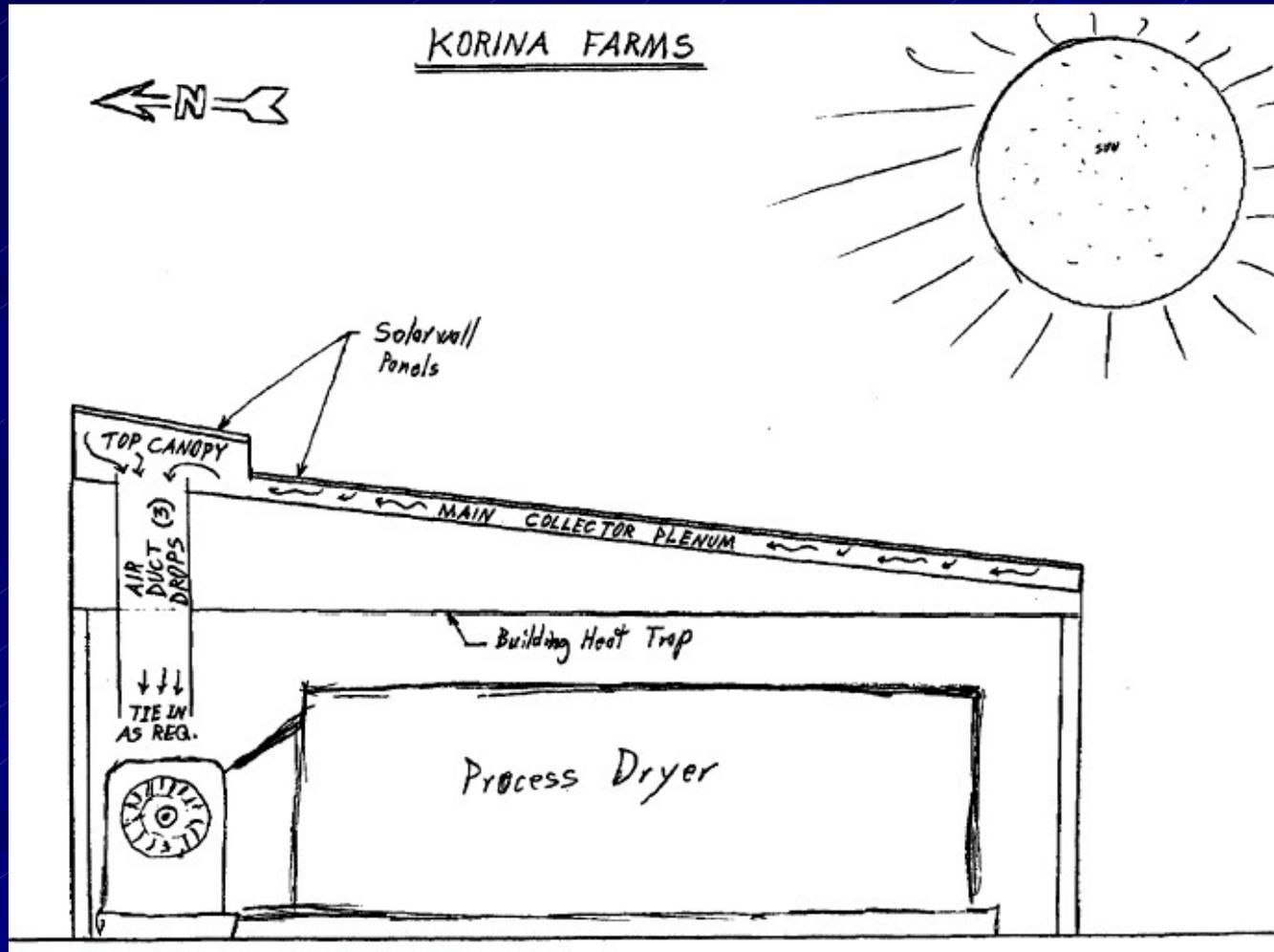
# Korina Farms (pecans)



Fan Supply Duct (bypass open)



# Korina Farms (pecans)



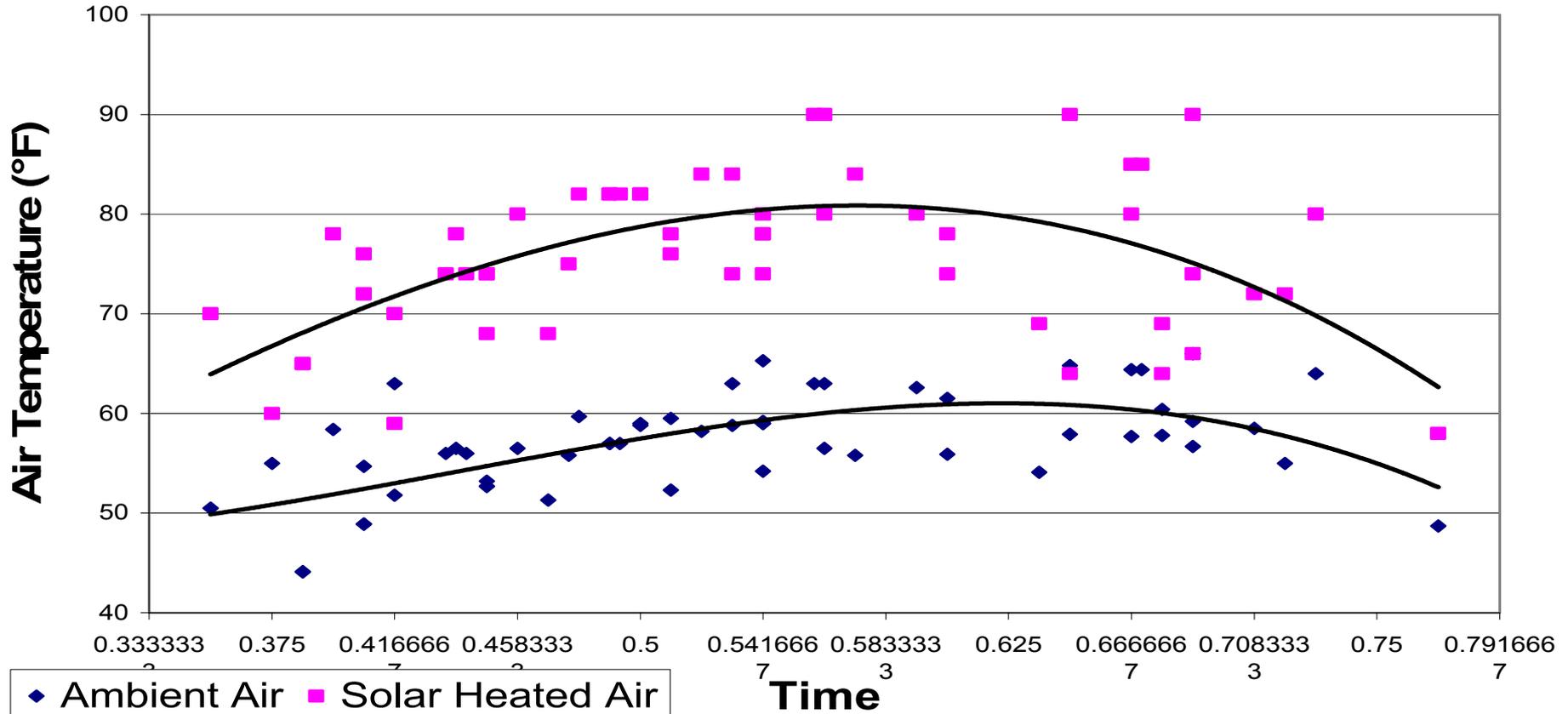
General Layout



# Korina Farms (pecans)

## Air Temperature vs. Time

Korina Farms - 2004 Solarwall Monitoring





# Korina Farms (pecans)

SOLARWALL Size	5,200 ft <sup>2</sup>
Air Volume Preheated	37,000 cfm
Projected Savings	163 MMBTU (per month of use)
Maximum Air Temperature	80° F



# Sonoma County Herb Exchange (various herbs)



Roof-Mounted Solarwall Panels



# Sonoma County Herb Exchange (various herbs)



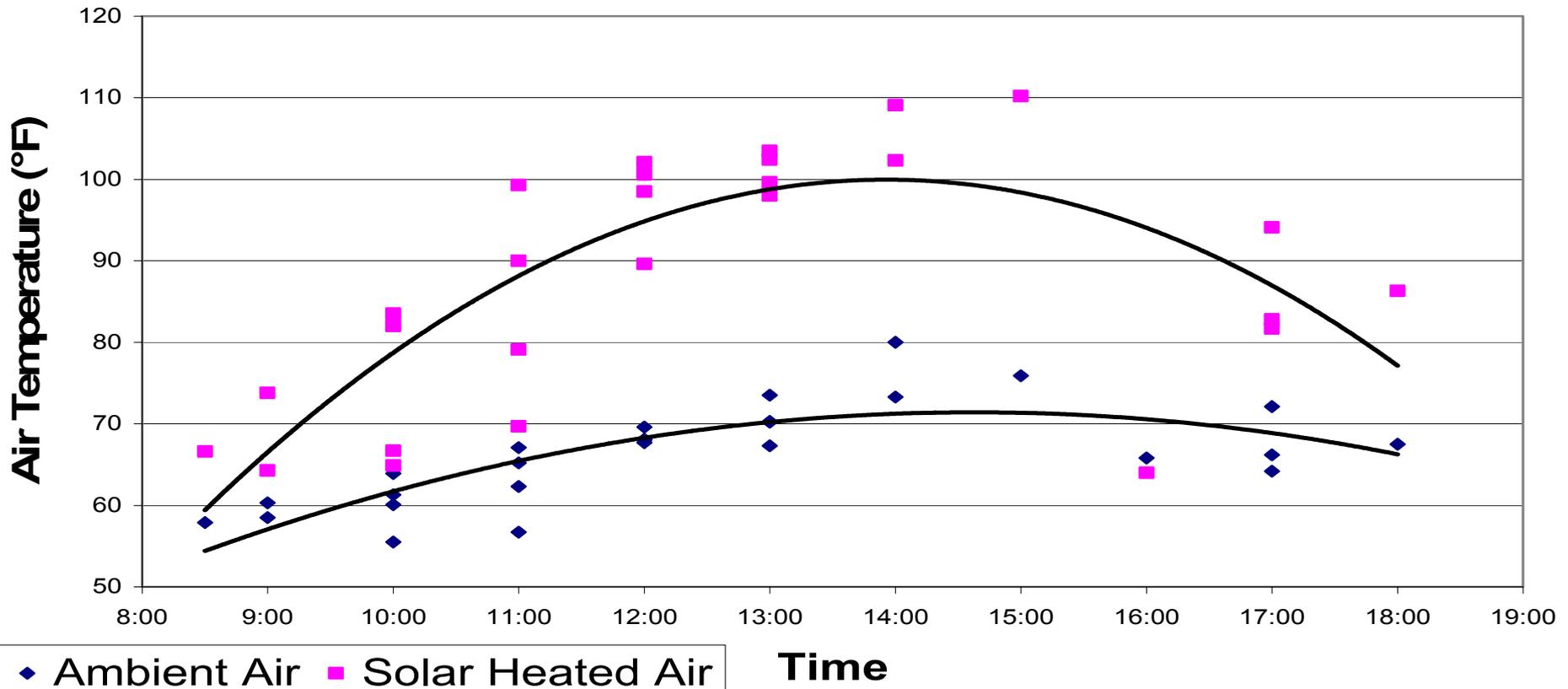
Solar Batch Dryer



# Sonoma County Herb Exchange (various herbs)

## Air Temperature vs. Time

Sonoma County Herb Exchange - 2005 Solarwall Monitoring





# Sonoma County Herb Exchange (various herbs)

SOLARWALL Size	105 ft <sup>2</sup>
Air Volume Preheated	350 cfm
Projected Savings	3 MMBTU (per month of use)
Maximum Air Temperature	none



# ICAT Summary

	Sunsweet	Carriere	Keyawa	Korina	Sonoma
	Prunes	Walnuts	Walnuts	Pecans	Herbs
SOLARWALL Size	1,225 ft <sup>2</sup>	3,200 ft <sup>2</sup>	9,300 ft <sup>2</sup>	5,200 ft <sup>2</sup>	105 ft <sup>2</sup>
Air Volume Preheated	10,000 cfm	17,500 cfm	65,000 cfm	37,000 cfm	350 cfm
Projected Savings (per month)	100 MMBTU	172 MMBTU	572 MMBTU	163 MMBTU	3 MMBTU
Months of Use per Year	1	2	2	2	12

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

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



# 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



# International Energy Agency

IEA Task 29 states – “One of the most promising applications for active solar heating worldwide is the drying of agricultural products.”





# International Energy Agency

## 3 Key Barriers:

- Lack of awareness
- Lack of good technical information
- Lack of good practical experience



# Café Duran – Panama

Coffee Drying





# Coopeldos – Costa Rica



Coffee Drying



# Coopeldos – Costa Rica



Solar Displaces Wood Fuel



# Drying Coir Pith – India



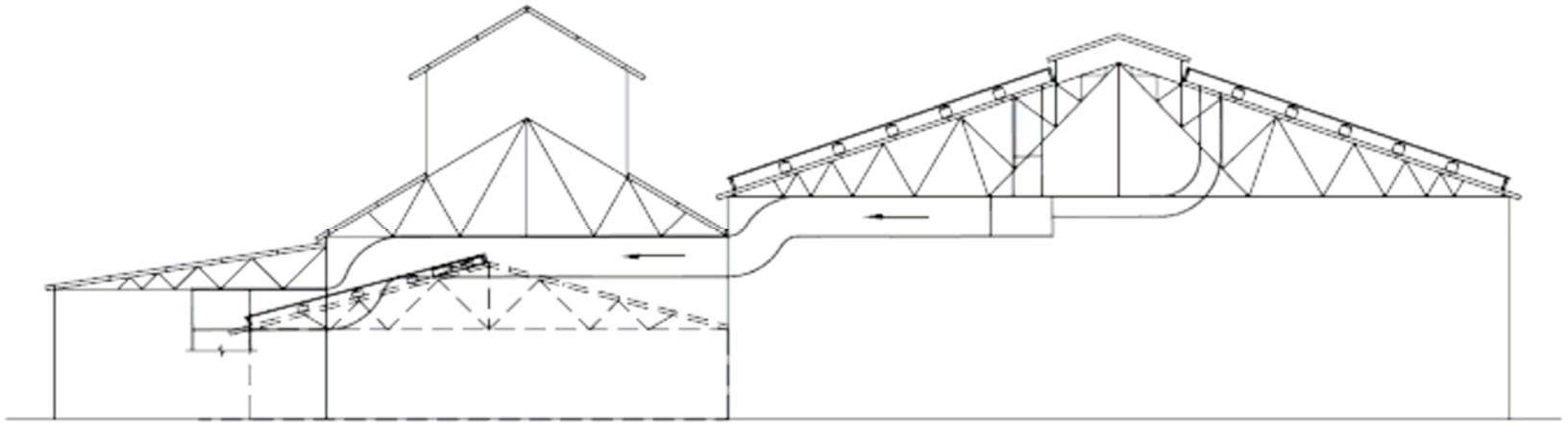


# Drying Coir Pith – India

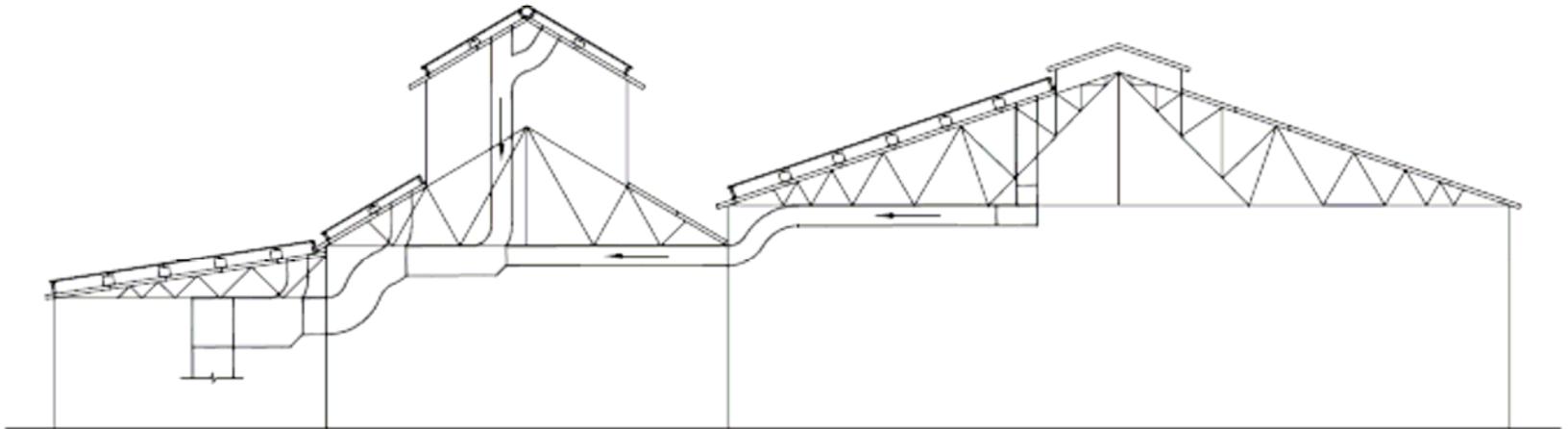




# Marionbarie Tea Co – India



B - B



A - A



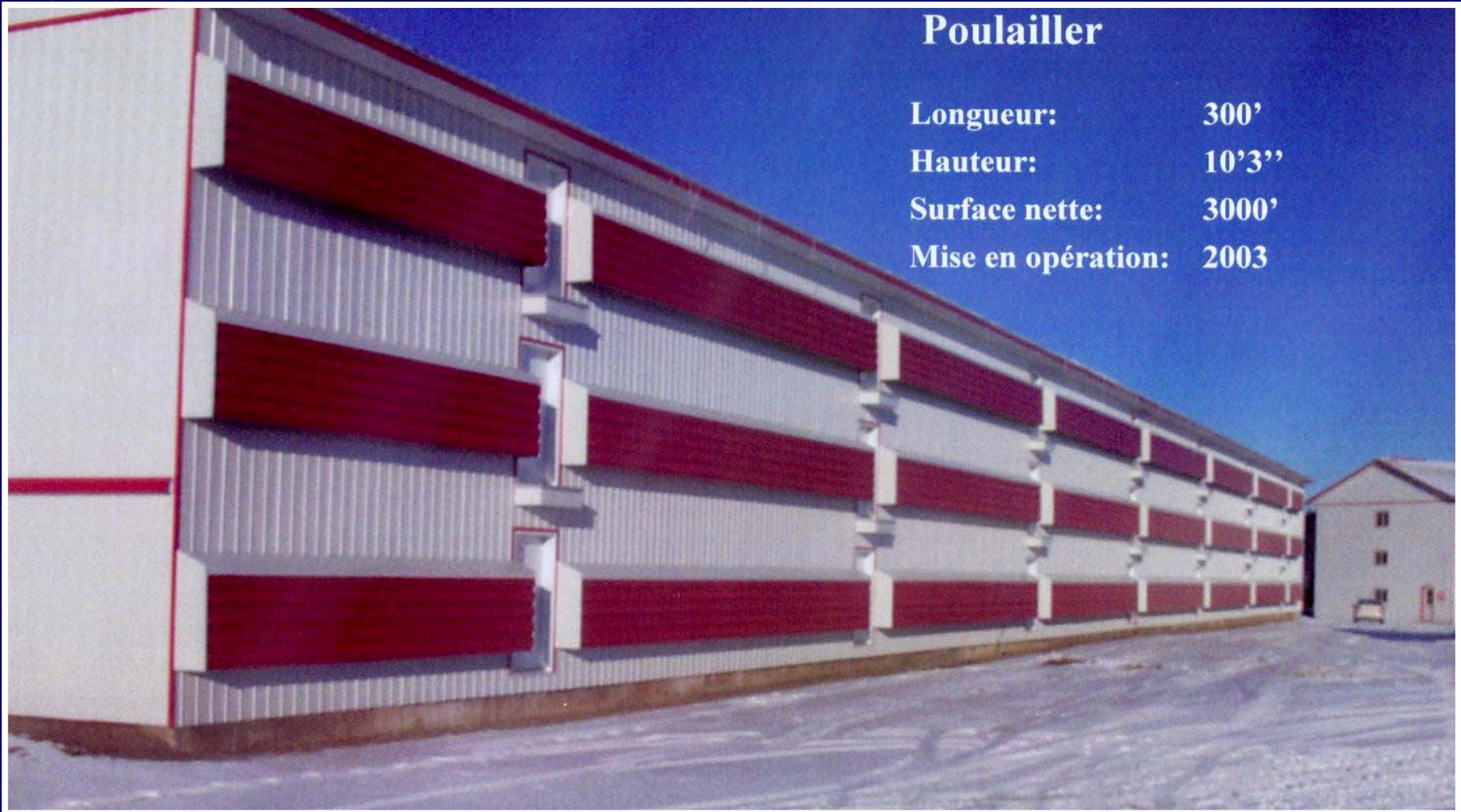
# Fruit Drying – China



Jujube Drying



# Chicken Barns – Quebec



## Poulailler

Longueur:	300'
Hauteur:	10'3''
Surface nette:	3000'
Mise en opération:	2003



# Manure Drying – Quebec



Drying Chicken Manure



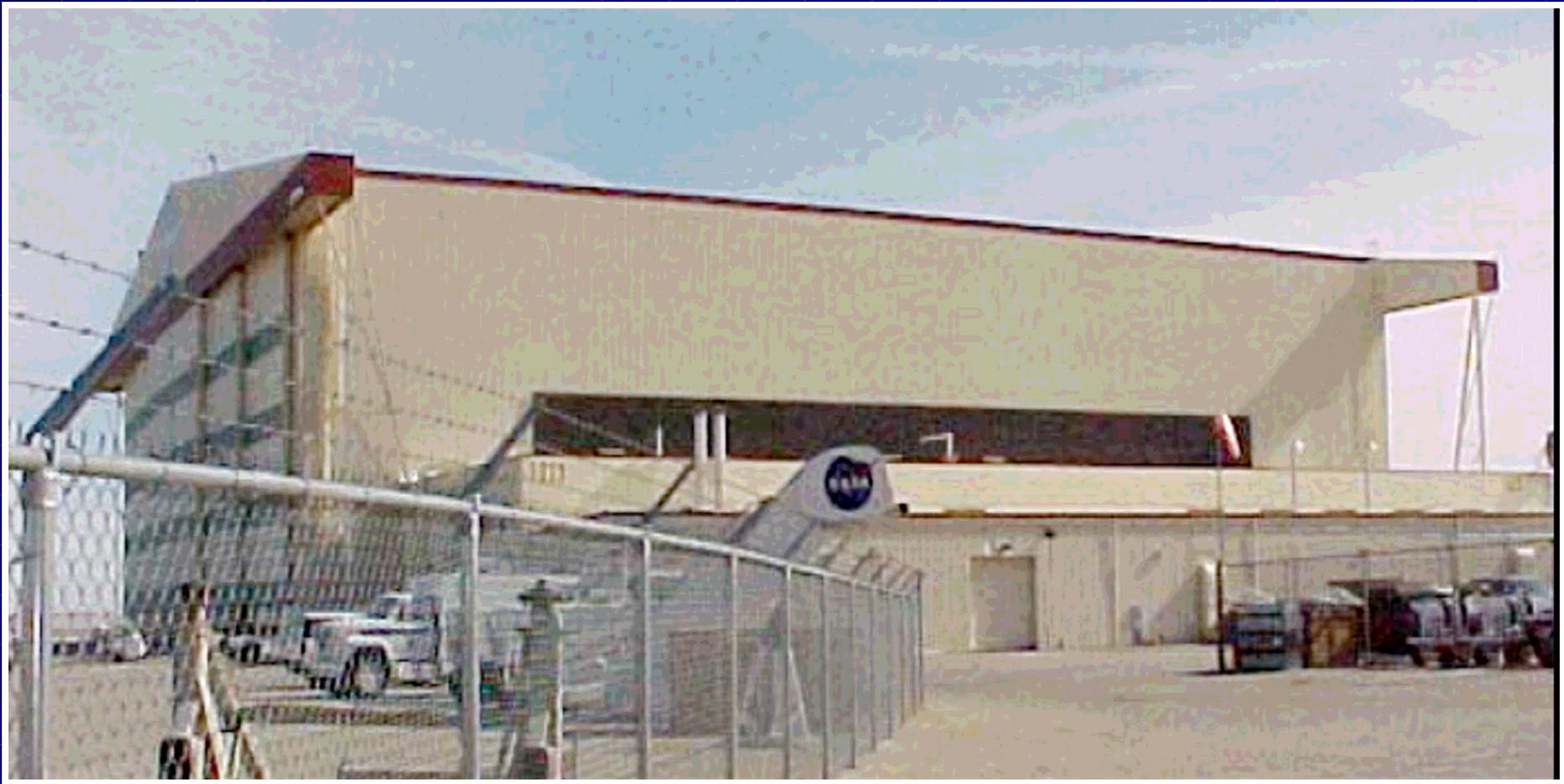
# Kreher's – Buffalo, NY



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](http://www.solarwall.com)

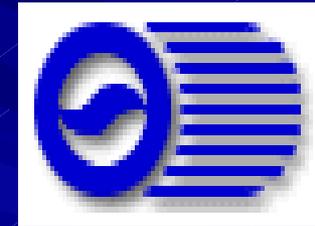
Email: [jhollick@solarwall.com](mailto:jhollick@solarwall.com)



**The California Air Resources Board**

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**International Energy Agency (task 29)**

[www.iea-shc.org/task29/](http://www.iea-shc.org/task29/)





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