U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Federal Energy Management Program

Energy 2005

Long Beach, California • August 14-17, 2005

The Solutions Network

Welcome to Session 8

Watt's Up with Solar Energy?

Energy 2005

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Solar Ventilation Air Preheating

Transpired Solar Collector

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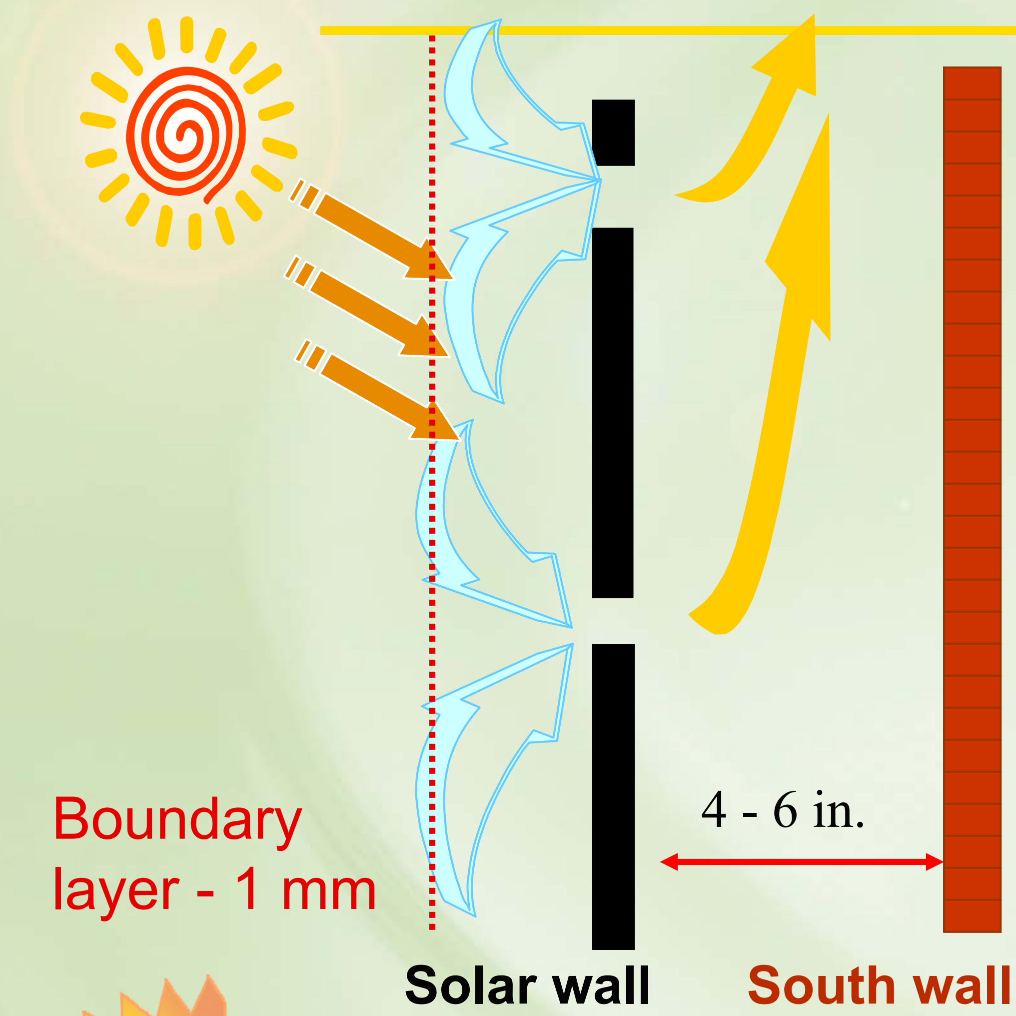
National Renewable Energy Laboratory

Federal Energy Management Program

Transpired Collector Principle



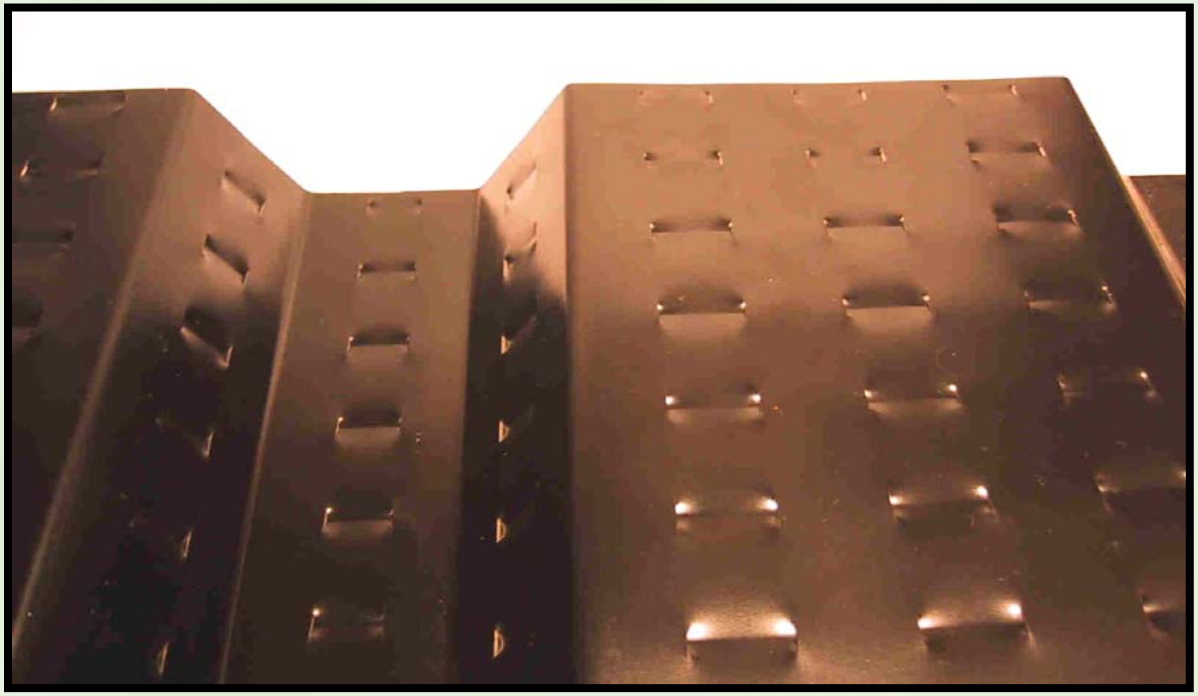
Sun warms the surface

Heat conducts from surface to thermal "boundary layer" of air 1 mm thick

Boundary layer is drawn into hole by fan before heat can escape by convection

Panel Properties

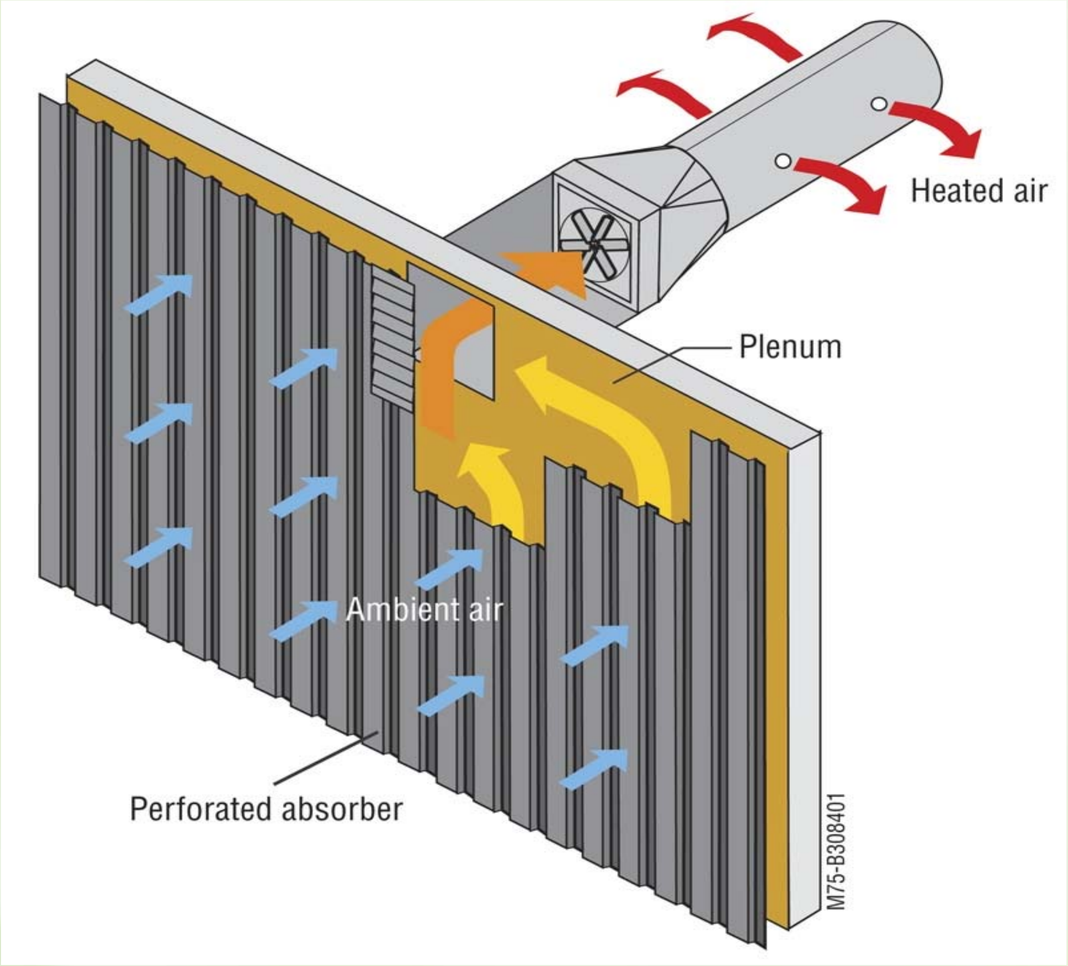
- Panels may be aluminum or steel
- Over 2,600 perforations per m^2
- Corrugated to increase structural rigidity



Typical Installation

- Supports create plenum
- Flashing around edges
- Installed over or around existing wall openings
- Installed over any non-combustible wall material
- Easy installation – no special skills or tools needed

Solar Ventilation Air Preheating System



Typical Connections

Heated air supplied directly into building:

- Solar-heated air is supplied directly to the building via a perforated flexible duct
- Ducting destratifies ceiling heat reducing heating load
- Suitable for both new and retrofit applications

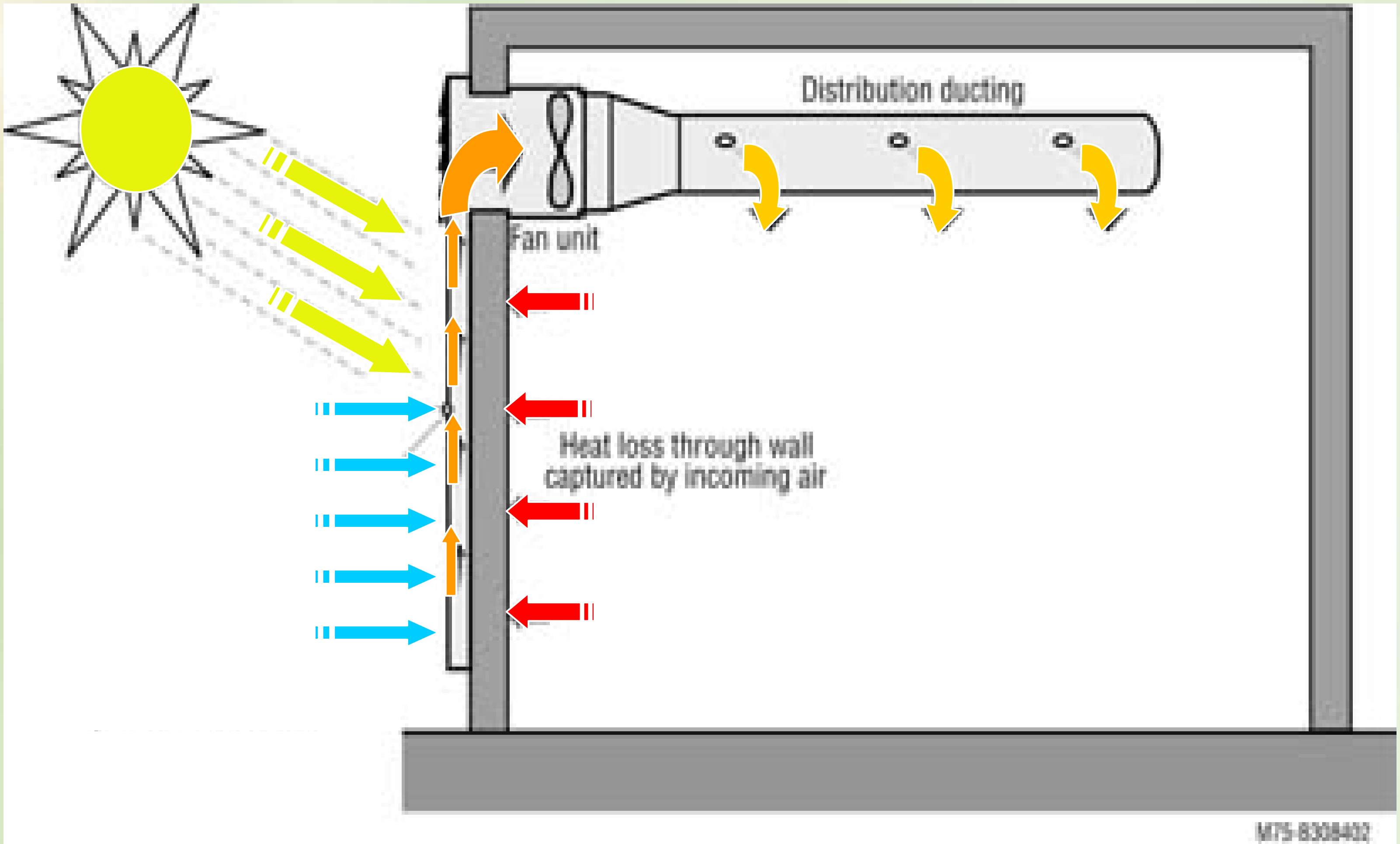
Typical Connections

HVAC intake preheater:

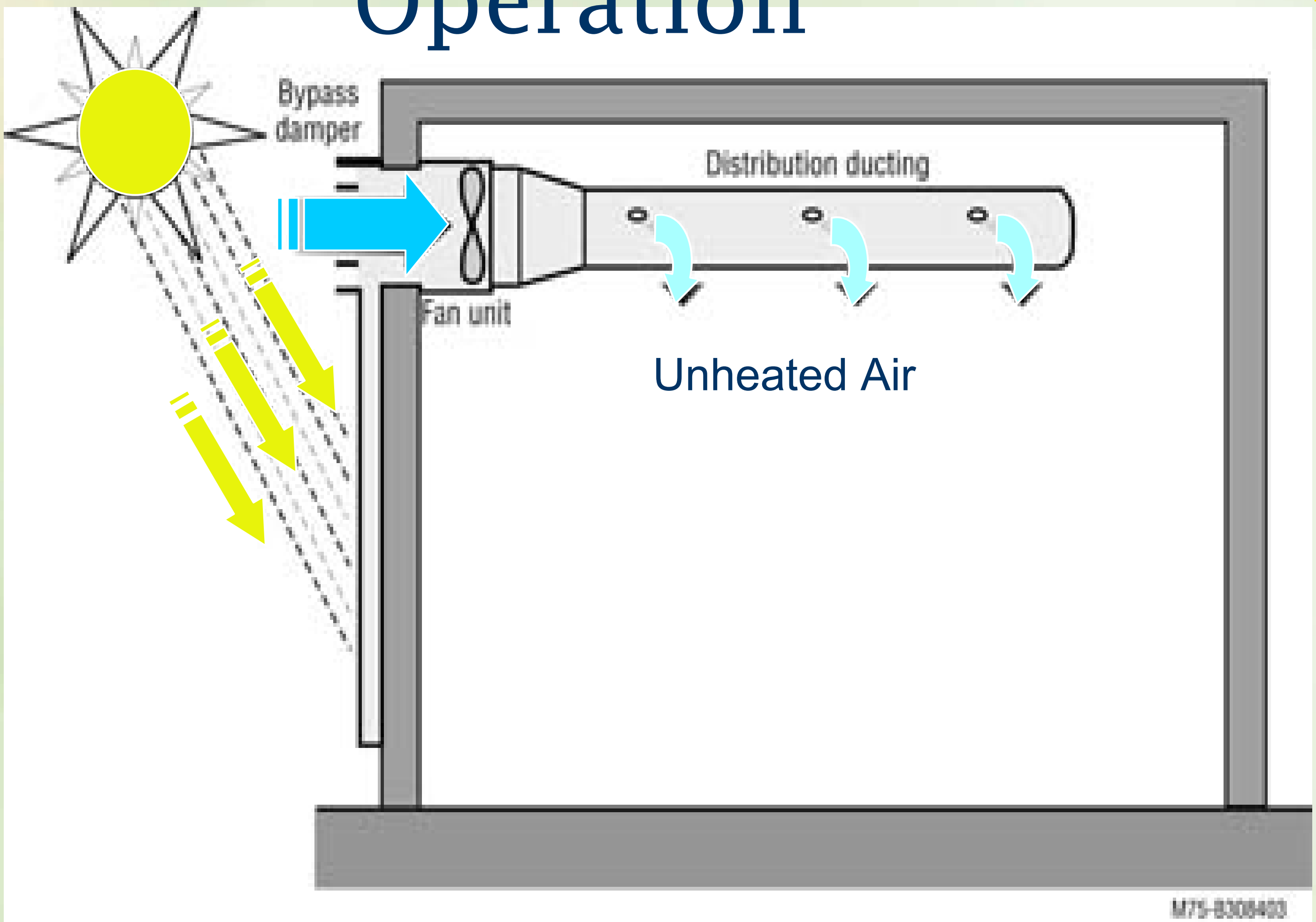
- Preheats air before entering air handler, thus reducing load on conventional heater
- Can be designed to work in a majority of situations, which makes it ideal for retrofit applications

Bypass Damper

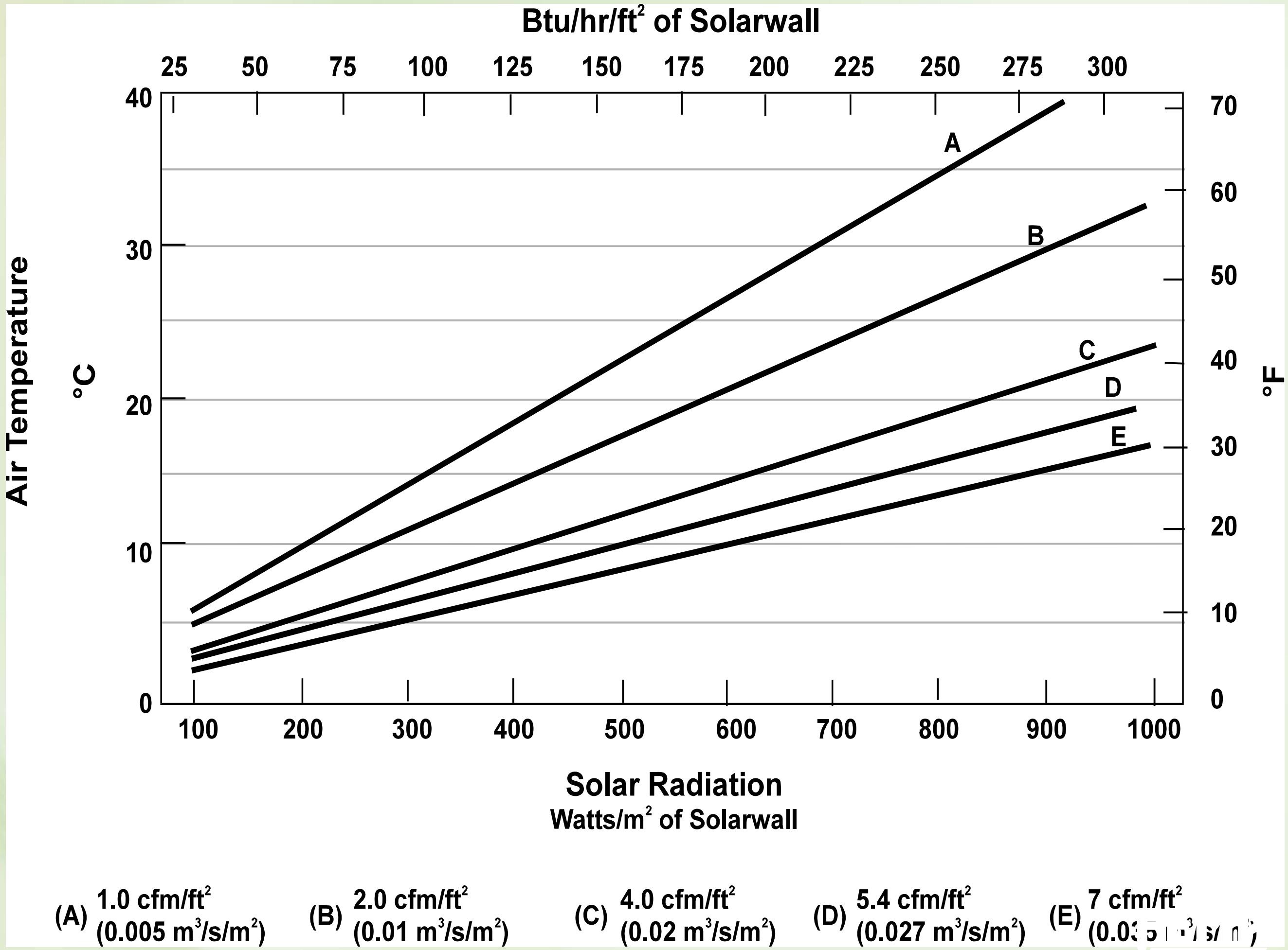
Winter Operation



Summer Operation



Air Temperature Rise



Typical Applications

Preheating ventilation air for:

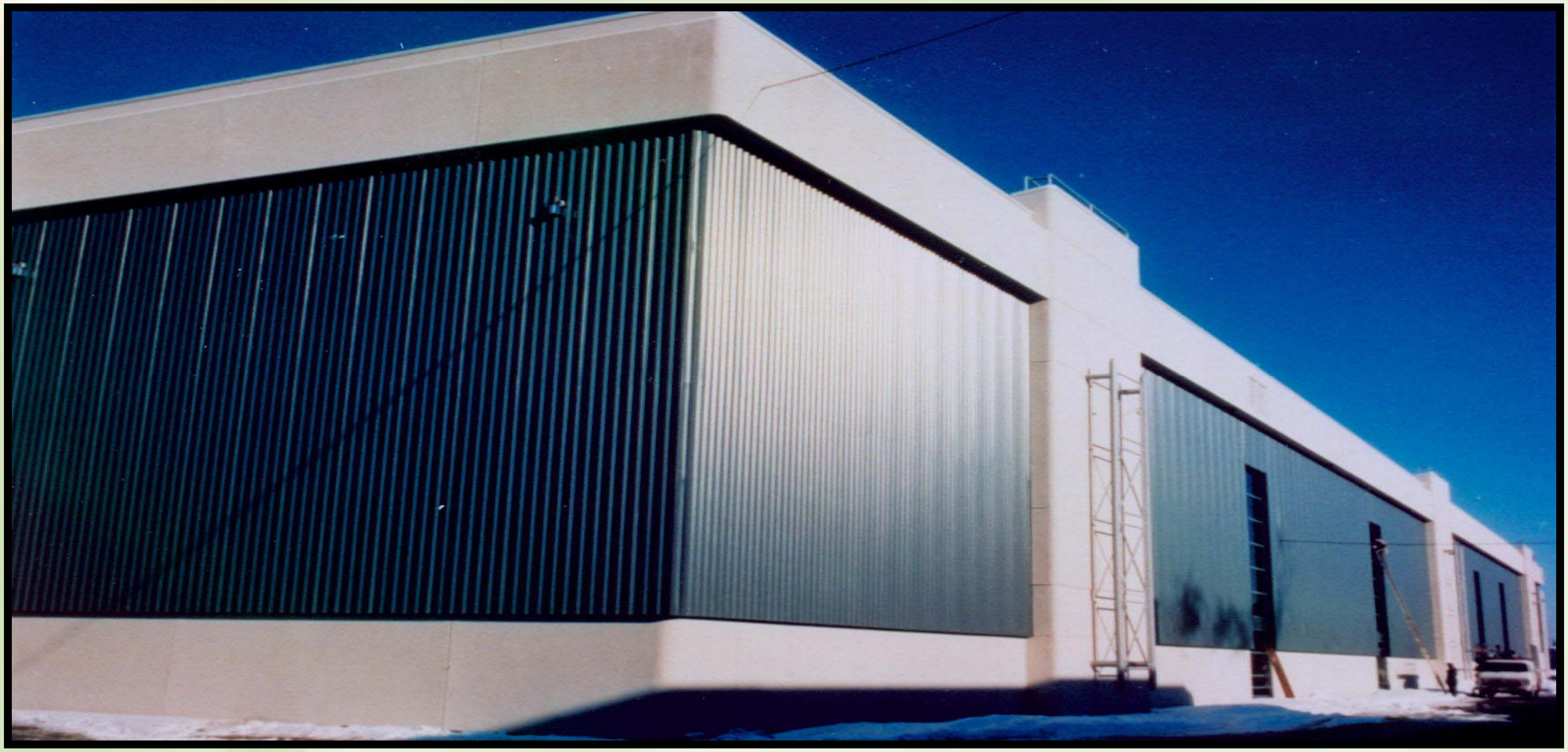
- Industrial and maintenance buildings.
- School and institutional buildings.
- Apartment buildings.
- Commercial and penthouse fans.
- Aircraft hangers.

Crop drying

Process air heating

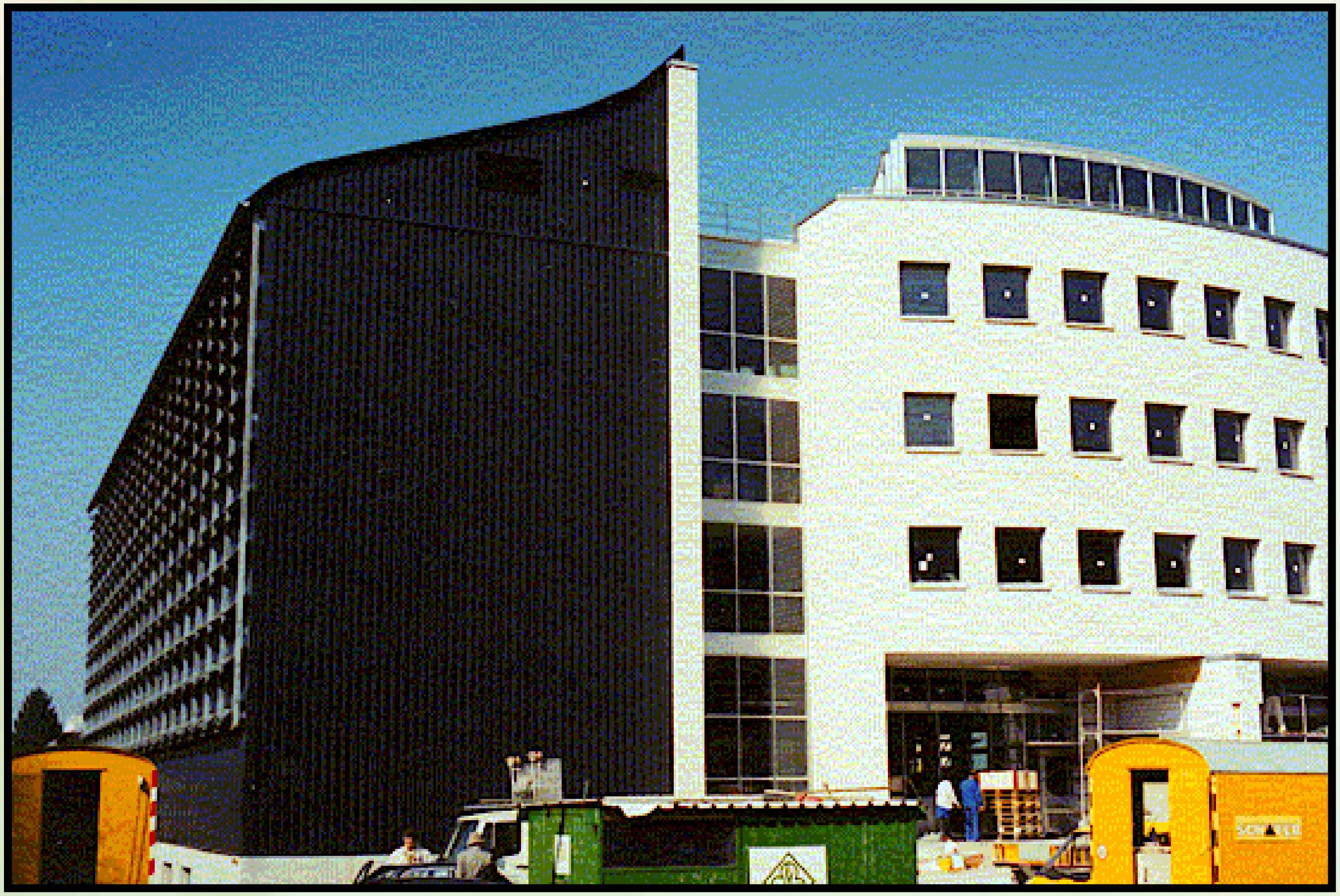
Combustion Air pre-heating

Industrial



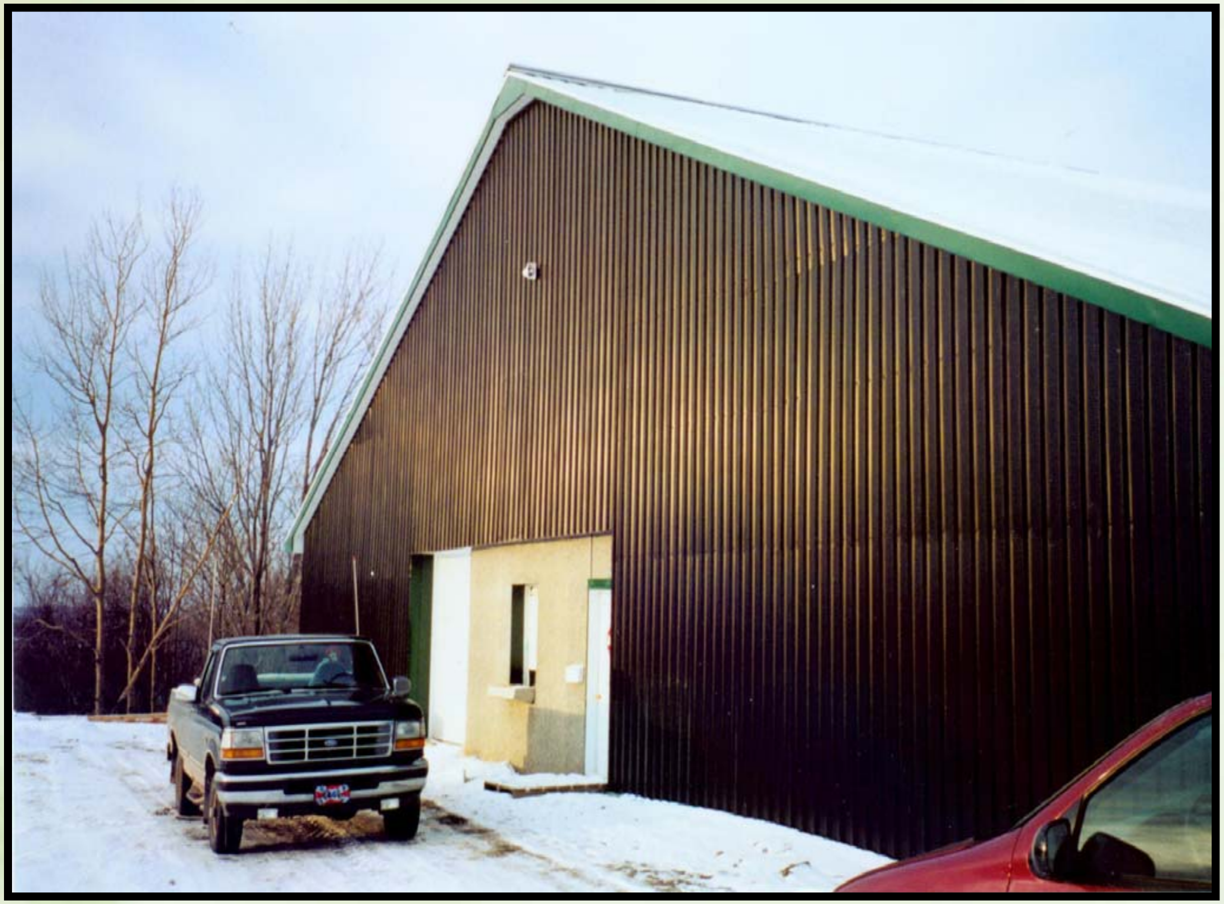
Bombardier's Canadair Assembly Plant – Ville St-Laurent, QC

Commercial



Wasag Building - Switzerland

Farming



Piggeries – Eastern Townships, QC

Schools

Alaittuq High School – Rankin Inlet, Nunavut

Retails

Winner of the 2001 AIA Top 10 Green Projects Award

BigHorn Home Improvement Center – Silverthorne, CO

Military

Fort Carson – Colorado Springs, CO

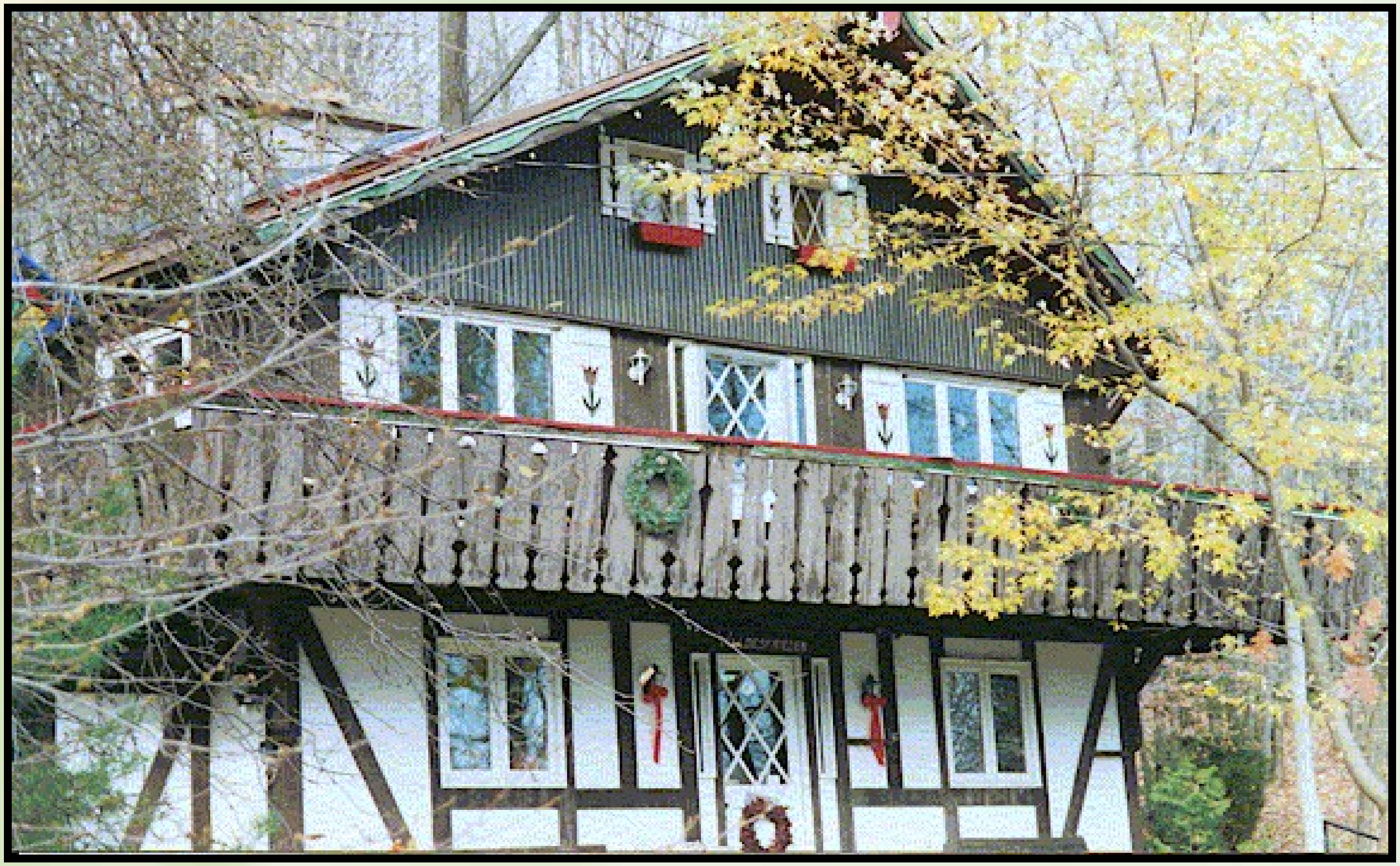
Community Centers

Rapid City Community Center – Rapid City, SD

Apartment Buildings

Windsor Housing Authority – Windsor, ON

Residential



Ski Chalet – Ellicottville, NY

Crop Drying

Carriere & Sons, California

(Walnut Drying)

Collector Sizing

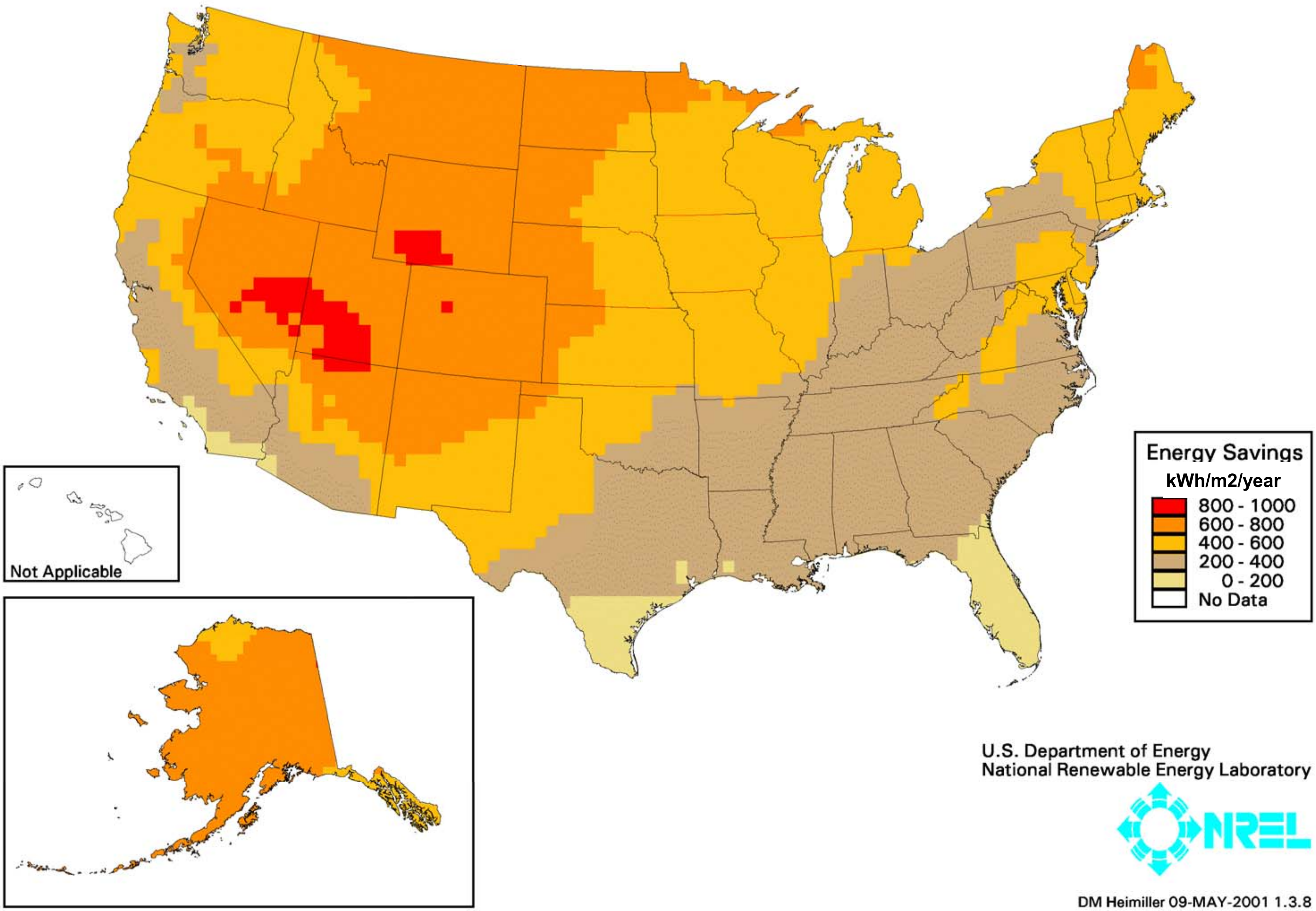
$A_c = V_{bldg} / v_{wall}$

A_c = solar collector area (ft^2), might be limited by available wall area.

V_{bldg} = building outside air flow rate (CFM)

v_{wall} = per-unit-area airflow through wall (typically 4 to 8 CFM/ft^2. If wall area is sufficient, use the lower value of 4 CFM/ft^2).

Energy Savings Utilitizing Solar Vent Preheating Technology



Thermal Energy Delivery

$Q_{solar} = A_c \ q_{useful}$ (#days per week)/7

$Q_{saved} = Q_{solar} / \eta_{heating}$

Q_{solar} = annual heat delivery of solar system (kWh/yr)

$\eta_{heating}$ = heating system efficiency (typically 70%)

Parasitic Fan Power

$Q_{fan} = A_c \, q_{fan}$ (# of hours/year)

q_{fan} = fan energy required to pull air through collector (typically 1 W/ft^2)

Advantages of Transpired Collectors

Very low cost.

Extremely reliable (no moving parts but fan).

No maintenance.

High Efficiency (up to 80%).

Operates near ambient temperature.

No problems with freezing or fluid leaks.

No storage required.

…other benefits

Recovers heat lost through south wall

Ventilation air introduced high in high-bay space

- destratifies air
- lower ceiling and exhaust air heat loss.

Positive pressure on building

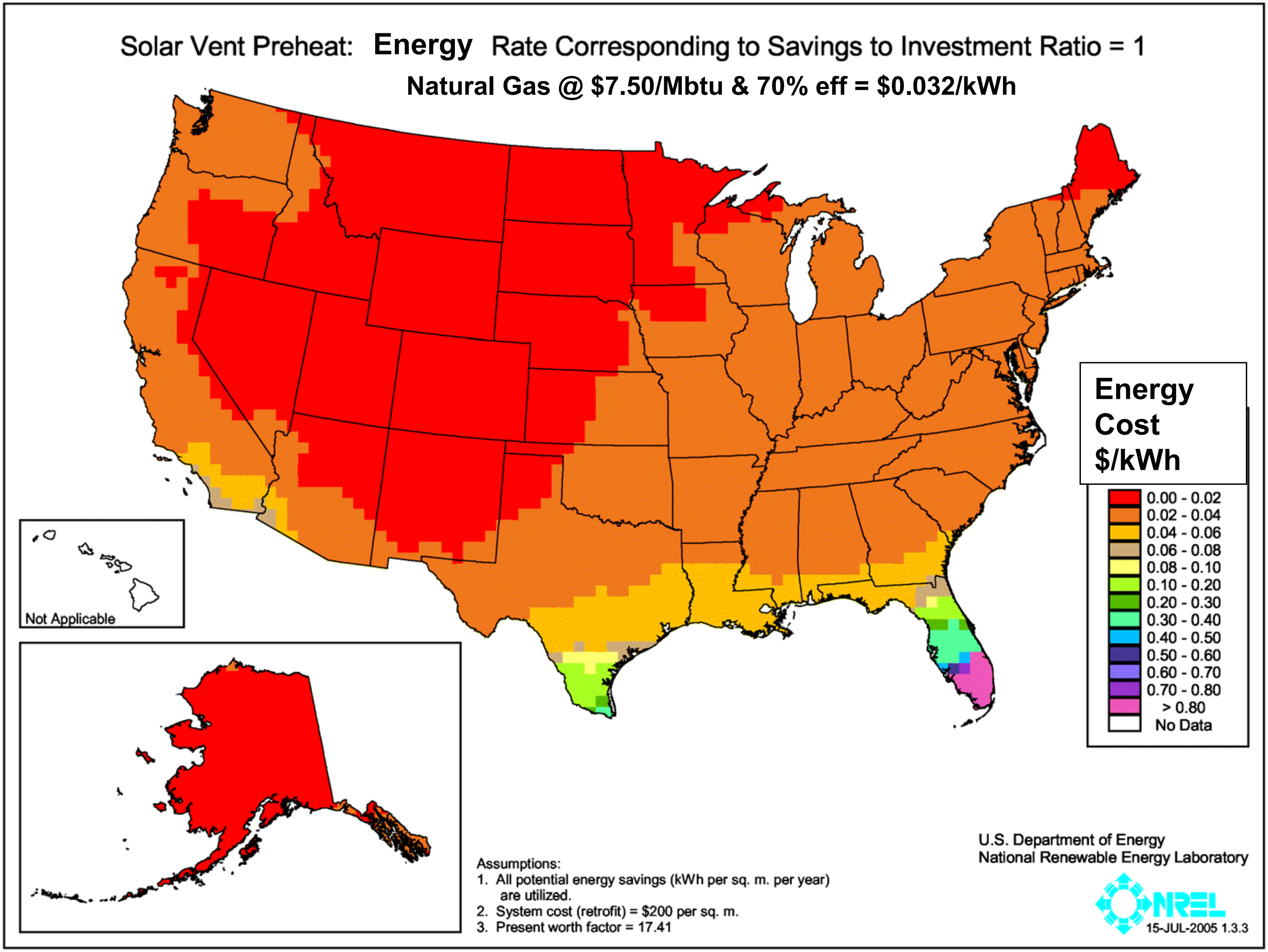
- reduces incoming drafts
- Increases comfort.

Looks better than an old, dilapidated facade

Solar Ventilation Preheat System Costs

Installation Costs in Retrofit Applications

Absorber	$9.50/ft^2
Supports, Flashing, Etc.	$2.50/ft^2
Installation	$4.00/ft^2
Other Costs	$4.00/ft^2
Total	$**20.00/ft^2**


Solar Vent Preheat: Energy Rate Corresponding to Savings to Investment Ratio = 1
Natural Gas @ $7.50/Mbtu & 70% eff = $0.032/kWh
Energy Cost $/kWh
0.00 - 0.02
0.02 - 0.04
0.04 - 0.06
0.06 - 0.08
0.08 - 0.10
0.10 - 0.20
0.20 - 0.30
0.30 - 0.40
0.40 - 0.50
0.50 - 0.60
0.60 - 0.70
0.70 - 0.80
> 0.80
No Data
Not Applicable
Assumptions:
1. All potential energy savings (kWh per sq. m. per year) are utilized.
2. System cost (retrofit) = $200 per sq. m.
3. Present worth factor = 17.41
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
15-JUL-2005 1.3.3

Case Study: NREL Chemical Storage

- 300 ft^2
- 3,000 CFM
- $6000 cost
- 63% measured efficiency
- Saves 14,310 kWh/year
- Saves $726/year of electric heat (no flames allowed in building)
- Payback = 8.3 years

Case Study: Ford Engine Assembly

- 20,000 ft^2
- Savings of 5,811 Mbtu/year
- Saves $30,000/year
  - 17% of plant's air heating costs
- 5 year payback period

Case Study: GM Battery Plant

- 4,520 ft^2
- 40,000 CFM
- Saves 940 Mbtu/year
  - Qsolar = 678 Mbtu/yr
  - Q htrec = 262 Mbtu/yr
- Saves $10,200/year
- Cost $66,530 ($14.72/ft2), including duct modifications
- Payback period = 6 years

Case Study: US Bureau of Reclamation

- Water treatment facility in Leadville, Colorado.
- Estimated savings are more than $4,000 per year
- 7 year simple payback.

Case Study: Federal Express Denver, CO

- 5,000 ft^2 (465 m^2) system
- 45,000 cfm
- saves 2,300 million Btu/year
- Saves $12,000 per year
- lease payments $4,800/ year
- FEDEX saves $7,200 /year for the 10 year term of the lease.

Design Considerations

South-facing is best, but not necessary

- +/- 20° of south gives 96-100% of south
- +/- 45° of south gives 80-100% of south

Black is best, but a wide choice of dark to medium colors may be used with efficiency loss of less than 10%

Design Considerations

Standard Colors

Black	Hartford Green	Rocky Grey	Hemlock Green	Teal
Classic Bronze	Medium Bronze	Regal Blue	Slate Blue	Slate Grey
Chocolate Brown	Boysenberry	Forest Green	Redwood	Patina Green

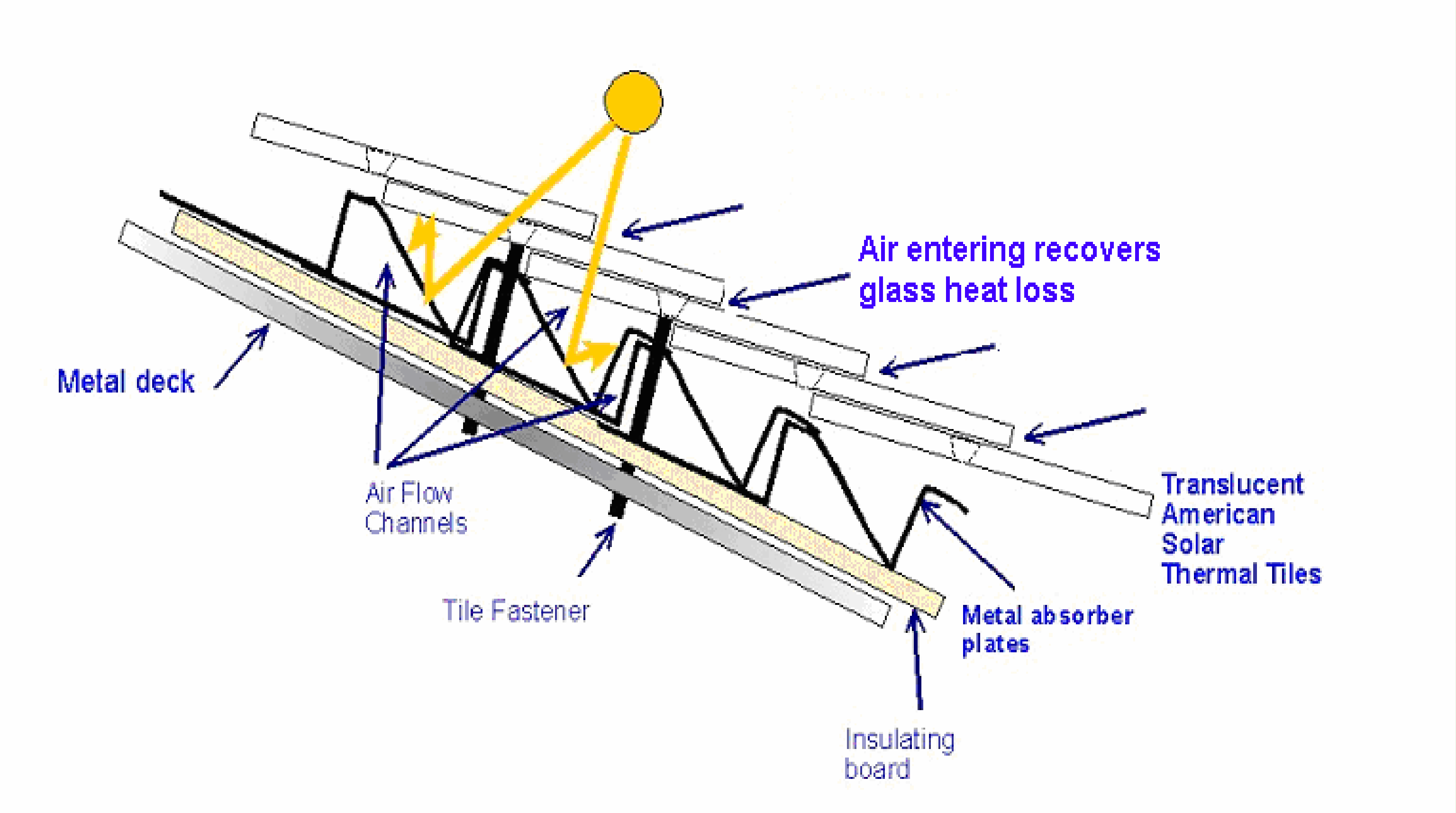
* Actual colors may differ from displayed colors

Solar Thermal + PV

Solar cogeneration – same surface area used for both heat & power production

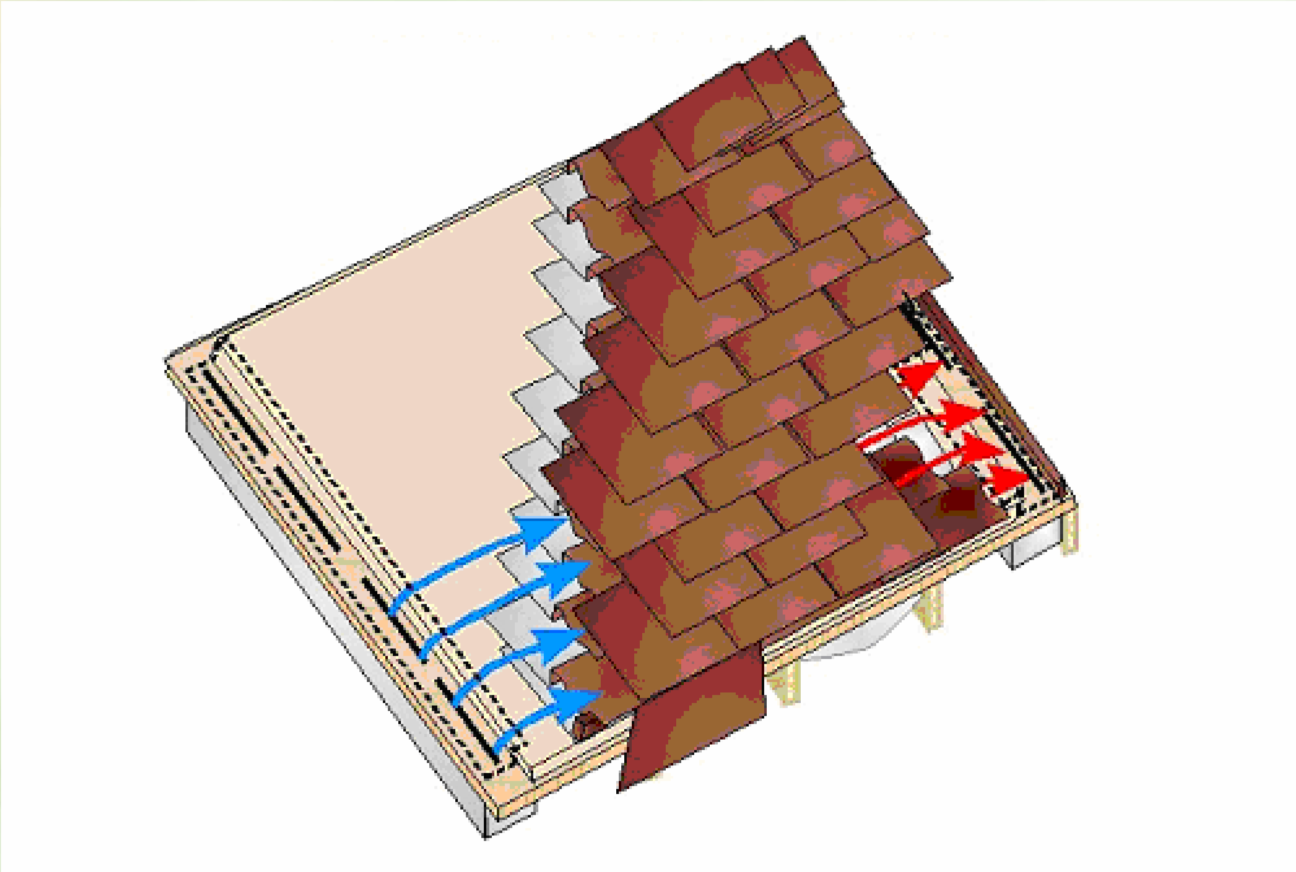
Chewonki Foundation Center for Environmental Education – Wiscasset, Maine

Solar Tiles Principle



American Solar, John Archibald

Solar Tiles Principle



Case Study: USGS Headquarters Reston, VA

- 480 ft2 in two arrays
- 12"x12" "diamond slate"
- Heat emergency generator enclosures
- Air is heated to about 70 degrees above ambient temperatures at an air flow rate of 1 cfm per square foot of tile surface.

Resources

- FEMP Federal Technology Alert http://www.eere.energy.gov/femp/technologies/techdemo_publications.cfm
- RETScreen International Simulation Software www.retscreen.net
- The Database of State Incentives for Renewable Energy (DSIRE) www.dsireusa.org
- Conserval Engineering, Inc www.solarwall.com
- American Solar http://www.americansolar.com/
- InSpire ATAS International Inc. www.atas.com
- National Renewable Energy Lab www.nrel.gov