Designing Solar Energy Systems to Reduce Energy Use and Operating Costs in Laboratory Facilities

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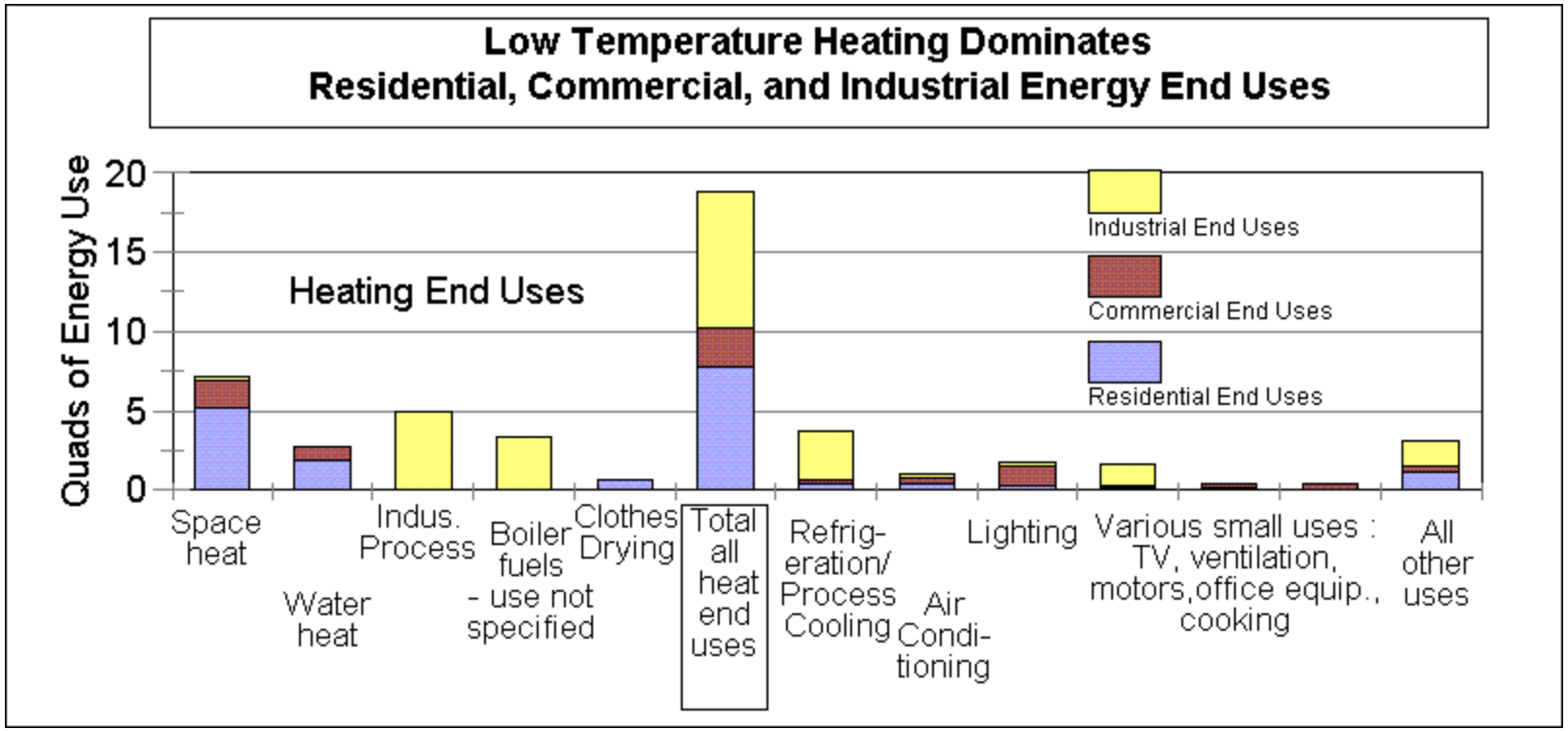
Designing Solar Energy Systems to Reduce Energy Use and Operating Costs in Laboratory Facilities

- **Laboratory Energy Goal:**
  - **Provide the energy needed**
  - **to do the job**
  - **at the lowest cost**

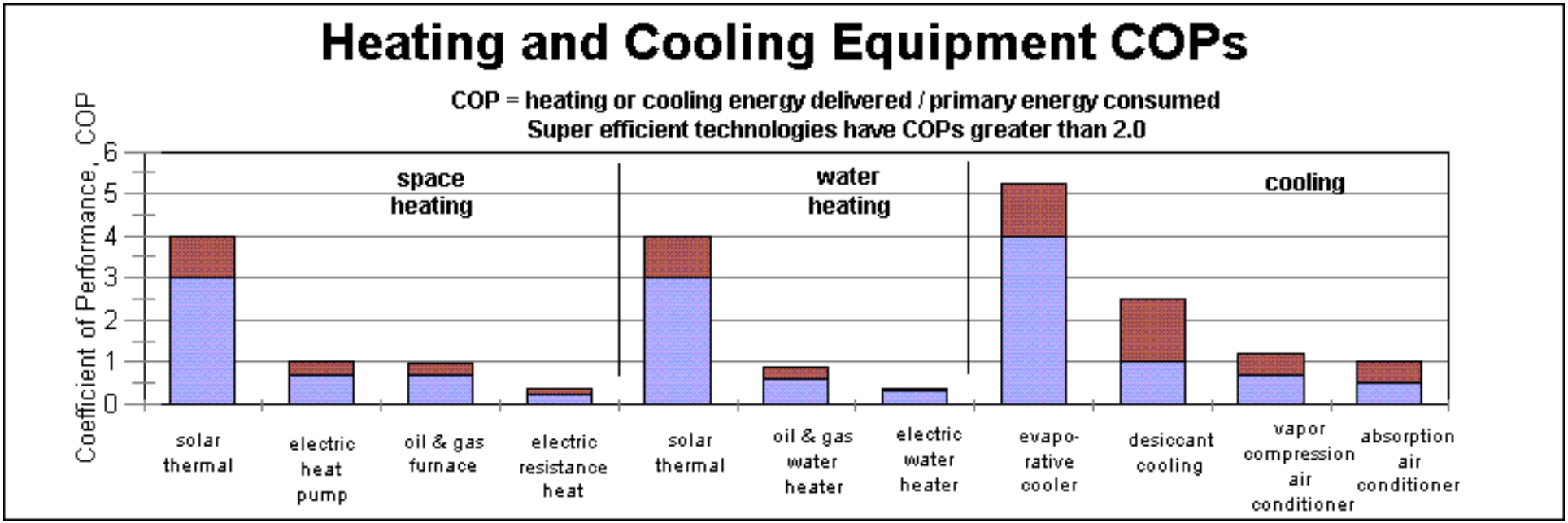
US Building Energy Use



Intensive Energy Use in Laboratories

- High ventilation air heating, dehumidification, and cooling loads
- High process heating and cooling loads
- Building lighting
- Emergency power
  - to maintain life and safety,
  - maintain environments for experiments,
  - preserve samples

Efficiency of heating and cooling energy technologies



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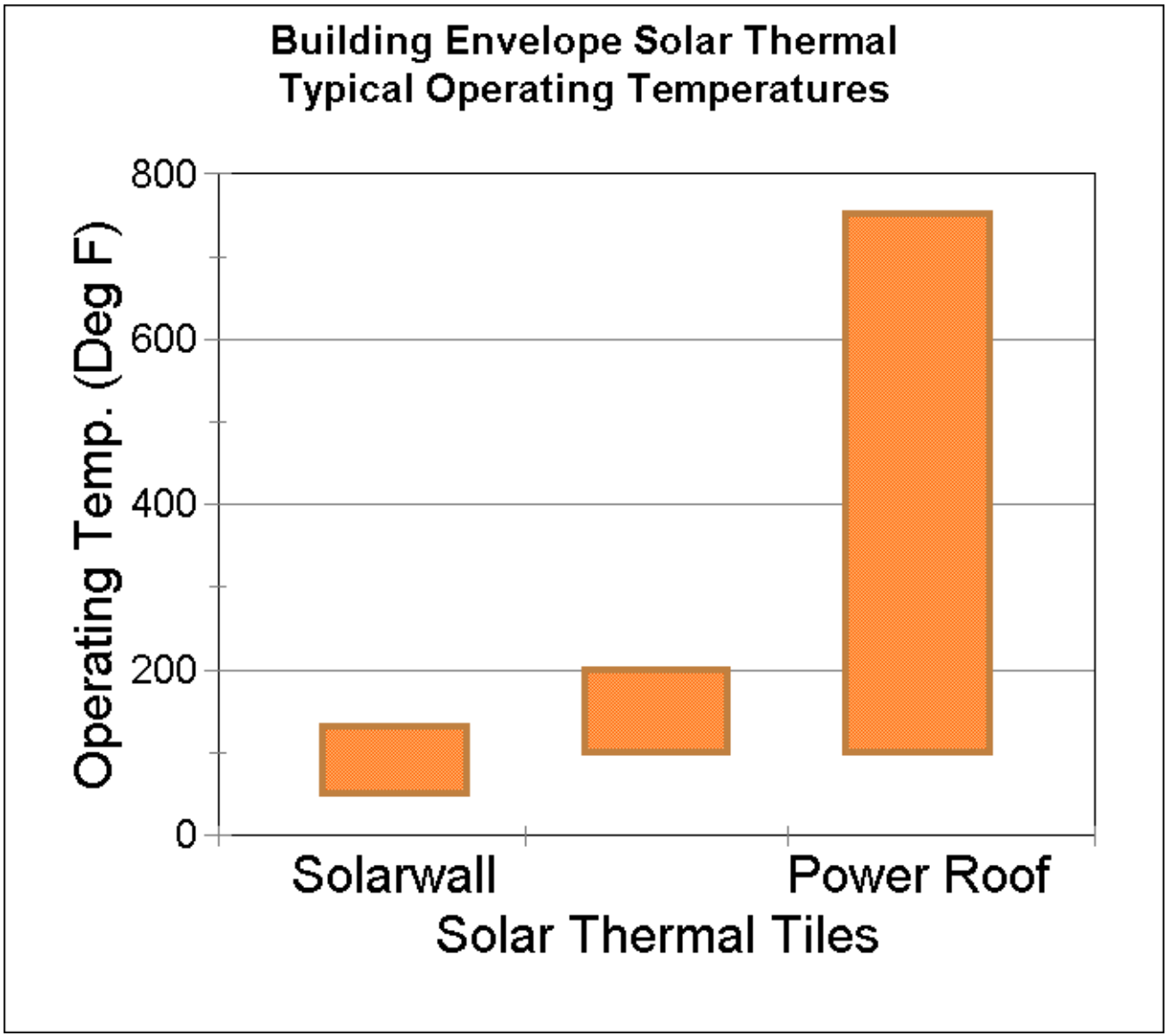
Solar heating technologies for laboratories

- Building Envelope Solar Thermal
  - Solar Thermal Tiles, Solarwall, Power Roof
- Ground and rack mounted systems
  - Solar Thermal Tiles, Flat plate water heating, Parabolic trough systems, Evacuated tube collectors, Unglazed water heating collectors, Transpired collector, Unglazed air heating collector


Building Envelope Solar Thermal
Typical Operating Temperatures
Operating Temp. (Deg F)
800
600
400
200
0
Solarwall
Power Roof
Solar Thermal Tiles

Solar Thermal Tile System

- Uses slate/tile technology to create a weather tight roof and **solar heated air**
- Suitable for sloped roof or roof facade
- Optional indoor air to water heat exchanger

Solarwall transpired collector

- Preheats ventilation air by pulling through a perforated wall panel
- Suitable for south facing walls and roof facades

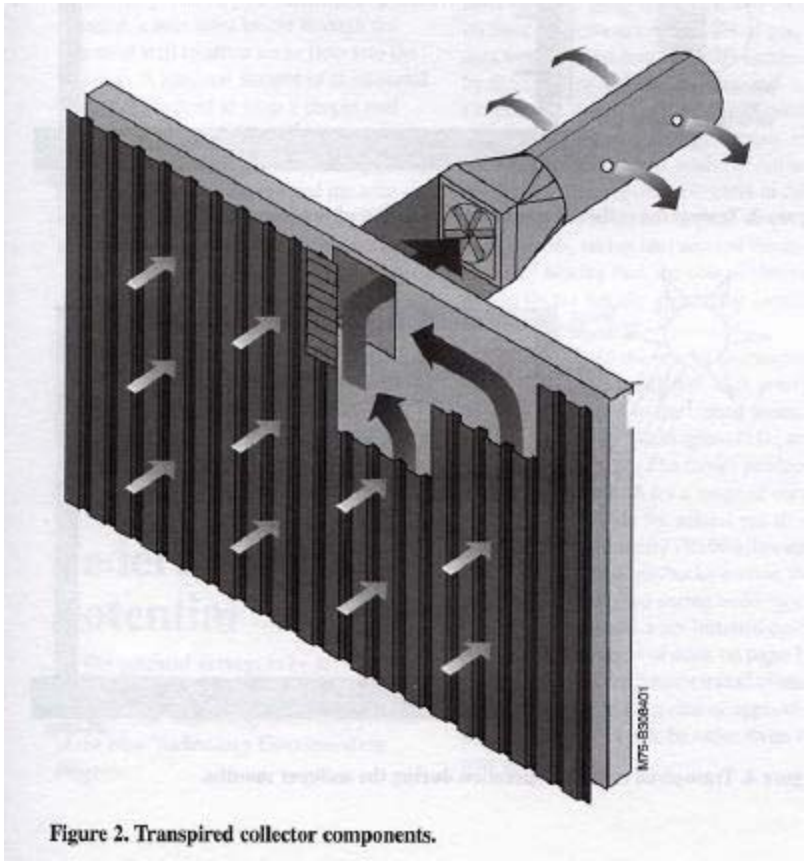
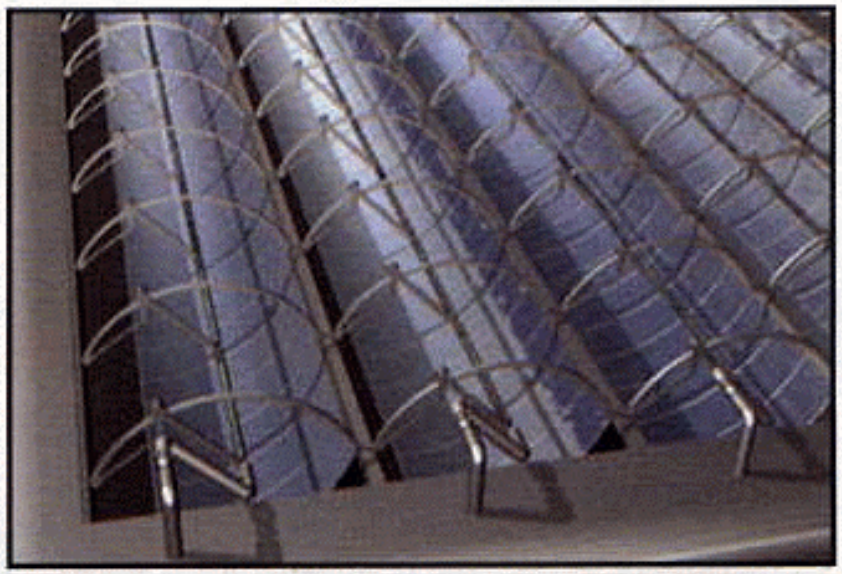


Figure 2. Transpired collector components.

Power Roof

- Builds concentrating trough into roof for heating, daylighting, and absorption cooling
- Suitable for new construction roof



The Power Roof™ technology will be integrated in the new building to provide for absorption cooling, hot water, space heating and daylighting.

Solar technologies for lighting and communications

- Solar daylighting
  - windows - best in new construction
  - skylights - best for flat roof, over large open bay areas
- Solar outdoor lighting
  - PV lighting for streets, walkways, signage
  - cost effective when trenching a power line is averted
- Communications
  - Emergency call boxes
  - powering remote facilities

Solar Electric Technologies

- Photovoltaic (PV)
  - Create direct current from sunlight
    - Expensive to convert to AC, store in batteries, or connect to the grid
  - Suitable for remote electric power
    - “Remote” may be within a few feet of grid supplied electricity
  - Several hundred million dollars in subsidies available each year
- Solar thermal electric
  - Solar heat to steam to electricity
  - Useful for combined electric and heat loads

What makes a good solar technology application?

- Target year round loads
  - or combinations of loads (heating and air conditioning or summer dehumidification)
- Provide “a portion”, not the peak annual load
- Minimize conversion and storage of the collected solar energy
- Look for high solar collector efficiency
  - 10-30 units of energy delivered for each unit used to run fans or pumps
  - greater than 20% of solar energy converted to useful heat or electricity

What makes a good solar technology application?

- Displace the most expensive energy sources
  - electric resistance heat, propane,oil heat
- Look for low installed costs for solar
  - under $25 per installed square foot
- Building integrated systems lower overall cost
  - makes the collector do double duty (weather envelope and energy production)
- Tax credits and accelerated depreciation allowed for commercial systems
- Aesthetics are often more important than technology

Standby heating of emergency generators

New Application

- Electric heaters keep engine jacket water at 130 deg F all year
- 2-8 KW typical load
- Solar heated air floods generator enclosure, reduces electric heating
- Warm air keeps engine ready to start
- Payback period from 2 to less than 10 years
- ‘Free’ storage building

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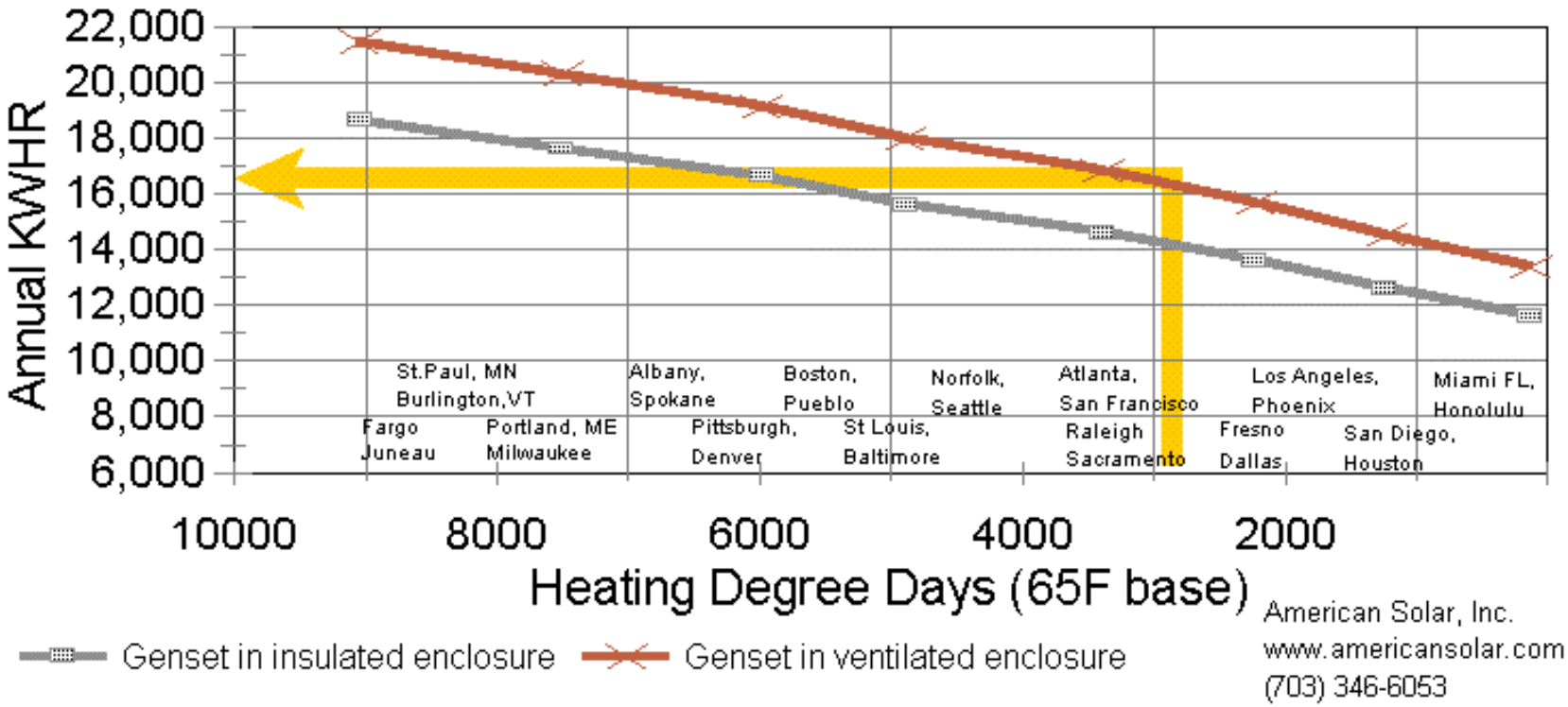
Generator Annual Energy Consumption

Annual KWHR vs Heating Degree Days

Read up from your heating degree days line for your type of generator enclosure, then read across for annual generator energy use



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Heat pump and boiler air preheating

- Heat pumps
  - Provide solar heated air for air-to-air heat pump evaporator
  - Solar heated water for water source heat pump
  - Boosts both collector and heat pump efficiencies
  - Can eliminate resistance heating below ~38 deg F
  - Excellent economics when integrated into a roof facade with nearby roof top heat pump units
- Boiler air
  - rule of thumb, every 40 deg F rise in air temp is a 1% improvement in boiler efficiency
  - every Btu in the incoming air is a Btu not required in fuel

Solar roof facades

- Air heating facades replace a ‘building’ component with a ‘solar’ component
- **‘Building’** roof facade gets **no tax credit** and requires **39 year depreciation**
- ‘**Solar’** roof facade gets
  - **10%** first year **tax credit** and
  - **5 year** accelerated **depreciation with** 1st year **bonus** and
  - **delivers heating savings**
- Study shows 24-76% rate of return to install solar roof facade on commercial office/lab
- Excellent with roof top heat pump preheating

Air-radiant, under floor heating

- Used in ancient Roman baths (hypocaust floor)
- Easily coupled with solar and heat pump
- Reduces required delivered air temperature,
  - improves solar productivity
- Reported as very comfortable heating system
  - Minimizes stratification from floor to ceiling
  - Air systems have quick response, low thermal mass
  - Through floor ventilation optional
- Space saving construction can minimize floor height (cost)

Future Developments

- Solar air conditioning
  - Absorption cycle is currently possible but requires high temperature and is expensive
  - 50 - 60% of summer AC load is from humidity from mid-Atlantic to Gulf coast, 60% of US AC expenses from this region
  - Dehumidification demonstrated with desiccant evaporative cooling cycle, patented in last 3 years
  - Compatible with lower solar air heating temperatures and new desiccant techniques
  - Year round solar load to speed cost effectiveness

Summary

- Several cost effective opportunities exist for solar energy use in laboratories
- Most opportunities are beyond the traditional solar water heating and photovoltaic power systems
- Many solar heating opportunities in ventilation, process, mechanical, and emergency generators
- Cost effective solar electric systems are more limited to ‘remote’ or heavily subsidized applications
- Building integrated thermal and electric systems can reduce overall installed costs
- Future developments are in air conditioning and building integrated heating and ventilation