# MULTIFAMILY PERFORMANCE PROGRAM
## Technical Topic – New Construction
## Solar Ventilation Preheater



### Introduction

A solar ventilation preheater has been developed in Canada by Conserval Engineering. One of these solar preheaters was installed on a high-rise multifamily building in Syracuse, NY, as part of a NYSERDA research project. The following information is the result of this demonstration project and is intended to assist architects, engineers, and contractors in the successful design and installation of solar ventilation preheaters on multifamily buildings in a New York State climate.

### Solar Preheater Technology

The solar preheater technology manufactured by Conserval Systems, Inc., Buffalo, New York uses perforated metal cladding attached to a southward facing wall of a building (see Figure 1). As the cladding (see Figure 2) is heated, a thermal boundary layer develops on the outside face of the cladding. Air from this boundary layer is drawn through the perforations and into the plenum region behind the collector. The air moves up through the plenum, along the side of the wall, and into the makeup air heater, which is typically located on the top of the building. The solar collector preheats the ventilation air, while the makeup air heater provides any necessary additional heating prior to distribution.

# Solar Ventilation Preheater

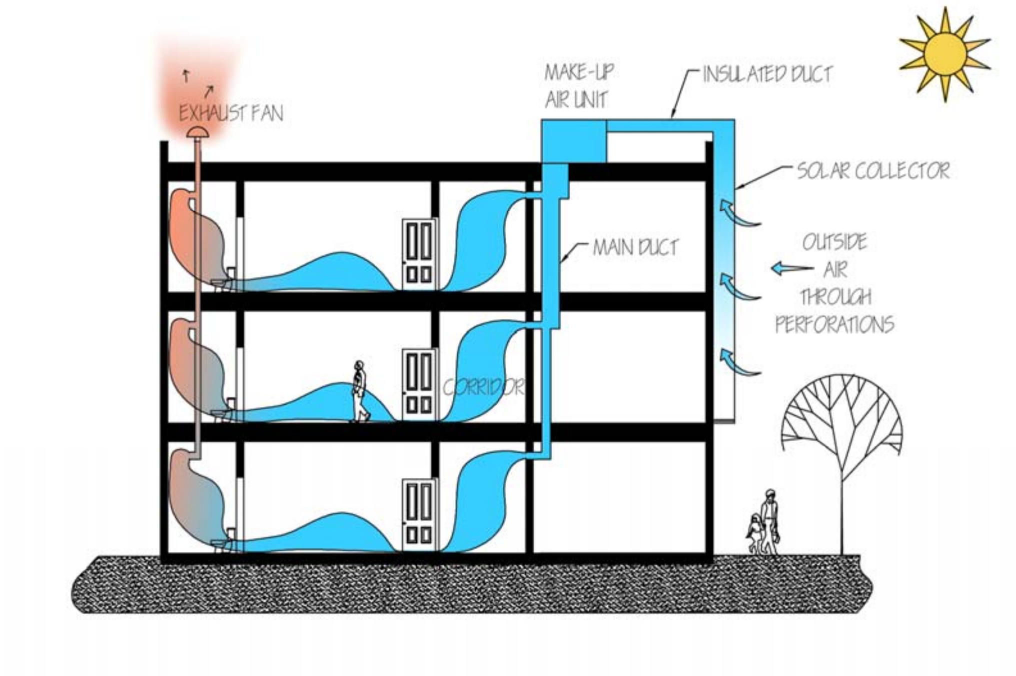


**Figure 1: Schematic of Solar Preheater Technology (Taitem Engineering)**

**Figure 2: Close-up of Solar Preheater Cladding (Photo: Taitem Engineering)**

### Features

Several features of the solar preheater make it an attractive option for ventilation in multifamily buildings. The collector uses no liquid and has no moving parts other than dampers; therefore, little maintenance is required. The coating on the cladding is designed to last for decades. It is reasonable to assume a life expectancy of 40 years for this system. A demonstration project in Syracuse indicated no degradation in performance from dust buildup on the cladding or in the perforations. Medium and high-rise buildings often offer ample wall space for collector placement. The heavy, continuous heating load during cold months is well suited to solar preheating in a northern climate.

### Energy Savings

Two software tools have been created for predicting the energy savings potential of these collectors. SWift and RETScreen both were developed by the Canadian government and are available at no cost on the Internet (www.canren.gc.ca, www.retscreen.net). SWift uses hourly weather data for the project location/city and project-specific design parameters to provide an estimate of annual energy savings. RETScreen is a simplified spreadsheet tool and uses monthly average weather data with project-specific design parameters to provide an annual savings estimate. SWift is not supplied with weather data files for New York State, but it can generate files for any New York State location if the user enters monthly-average data such as average daily horizontal radiation; RETScreen contains weather data for six different cities in New York.

### Structural

The building wall must be able to support the weight of the solar preheater and framing as well as any expected wind loading. For masonry, the framing usually can be attached anywhere on the wall. For prefabricated metal walls, the solar preheater framing must be attached to the metal structural supports and not directly to the metal face. A pull test should be performed to ensure that the wall can support the expected loads. Provisions should be made for expansion and contraction if the solar preheater straddles a building expansion joint.

### Configurations

Solar preheaters have been successfully installed on a variety of building types, including commercial, civic, and residential buildings. In apartment buildings, solar preheaters generally are installed on walls with the air pulled up to the rooftop.

A variety of options are available to place solar preheaters. One alternative is to place a strip of the solar preheater in one or more of the continuous spaces between windows. Another option is to place solar preheaters on stairwells. The stairwell exterior usually contains a large region free of obstructions that extends to the rooftop, which provides ample space in a more discrete location.

Walls that face within ±20° south are ideal, although walls within ±45° also may be effective. The walls should have minimal shading, but some shading may not cause a significant decrease in performance. Also, solar preheaters should not be ruled out because of cloudy weather. For example, the demonstration project located in Syracuse (a relatively cloudy city) has been working successfully and generating savings, as expected. In these cases, the impact of cloudiness can be offset by the high heating demand in northern climates.

## Ductwork

For roof-mounted systems such as those typically found in high-rise apartment buildings, extra ductwork is required to connect the solar preheater to the makeup air unit. This exposed ductwork must be insulated in order to minimize losses and to comply with the Energy Code. The ductwork also should be designed carefully to avoid water intrusion and wind damage. Rooftop ductwork should be anchored to the roof to prevent wind damage to the system.

To reduce wind loading, either round ducts or square ducts mounted on edge should be used instead of rectangular ducts. Round or edge-mounted ducts shed water effectively. Rectangular ducts are prone to water pooling on top, which can contribute to the deterioration of the duct system over the long term. Alternatively, the insulation on the outside of a rectangular duct can be tapered to shed water.

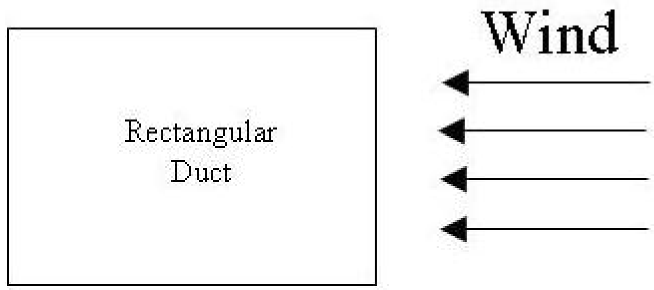


**Figure 3: Poor Wind Deflection, Ineffective Water Shedding**

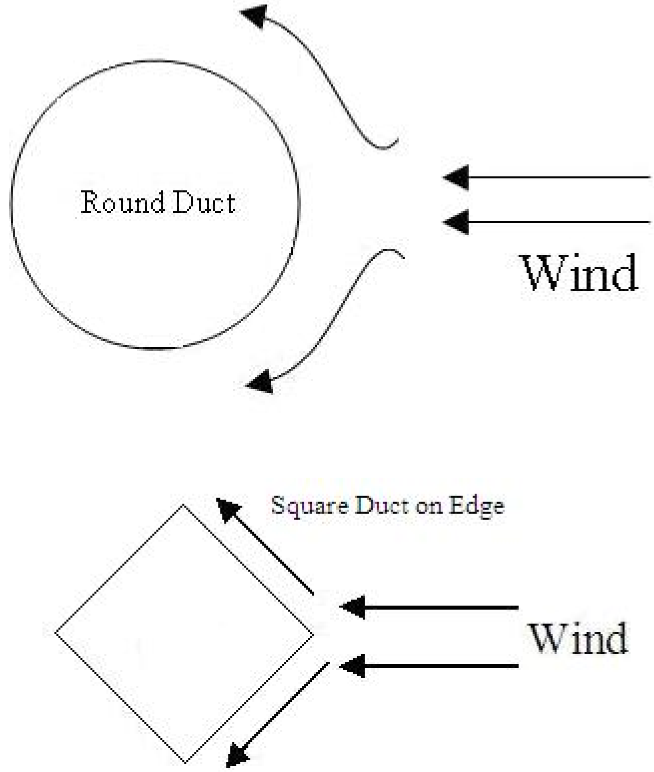


**Figure 4: Good Wind Deflection, Effective Water Shedding**

Although examples of both round and square-on-edge ductwork have been seen in rooftop ventilation installations, round ductwork is more common and lends itself to simpler mounting.

Rigid polyisocyanurate board is well suited to outdoor duct insulation. It has an R-value of 5.6 per inch. Fiberglass is another option, and has an R-value of 3.9 per inch.

Weatherproofing material is necessary to protect both the duct and the insulation from precipitation. Typically, vinyl mastic or aluminum jacketing are used. Experience with aluminum jacketing has been mixed; it has worked well on some projects and has caused problems on others. Polyguard Products Alumaguard 60 is a 60-mil thick rubberized bitumen, foil-faced, self-adhesive “peel and stick” weatherproofing that has worked well.

## Color

A variety of colors are available for the collector, and a complete list of all color options (with corresponding absorptivity values) is available from the manufacturer. Darker colors (higher absorptivities) result in better performance, although some light colors can perform quite well.

According to the algorithm used in RETScreen, the amount of useful heat captured by the solar preheater (and thus the energy savings) is proportional to the material absorptivity.

## Airflow Rates

Low, medium, and high flow rate solar preheaters support a wide range of airflow rates. (The only difference is the size of the perforations). The flow rate, solar preheater area, and solar radiation (location-dependent) combine to yield the expected air temperature rise. Research on solar preheater performance conducted in the 1990s suggested that flow reversal (air flow out of the collector rather than in) can be a problem under certain conditions. The National Renewable Energy Laboratory recommended that the bulk air entering velocity, defined as the total airflow divided by the total area of the collector, not be allowed to drop below 4 CFM/SF to avoid flow reversal (Kutscher). Other research recommends a range of about 3.4 CFM/SF to 7.7 CFM/SF depending on building shape and dominant wind direction (Gunnewiek).

## Air Pressure Drop

The manufacturer estimates a 25 Pa pressure drop across the cladding itself and a total pressure drop of 50 Pa –100 Pa from the ambient to the fan. Actual pressure drops should be evaluated based on project-specific conditions.

## Controls

The control strategy for a solar preheater is relatively straightforward (see Figure 5).

Collector dampers control the amount of air coming from the collector, and bypass dampers control the amount of ambient air taken in directly from the outdoors (bypassing the collector). The dampers should be specified as low-leakage. A temperature sensor, located in the supply duct downstream of the collector and dampers, regulates opening and closing of the two dampers to maintain a constant supply temperature (typically 70 F) to the downstream makeup air system. Typically, the bypass dampers are fully closed and the collector dampers are fully open. If the solar preheater cannot maintain the desired setpoint (in other words, if the mixed air temperature is below 70 F), supplemental heating is provided by the makeup air system. If, conversely, the solar collector has overheated the air above 70 F (during spring and fall days, for example), the collector dampers modulate partially closed and the bypass dampers modulate partially open to allow unheated outdoor air into the ductwork. The two sets of dampers modulate in opposing directions, until the mixed air temperature is 70 F. If the outdoor temperature rises above the setpoint, the bypass dampers are fully open and all the outdoor air flows through these dampers, while the collector dampers are closed and no air flows through the collector.

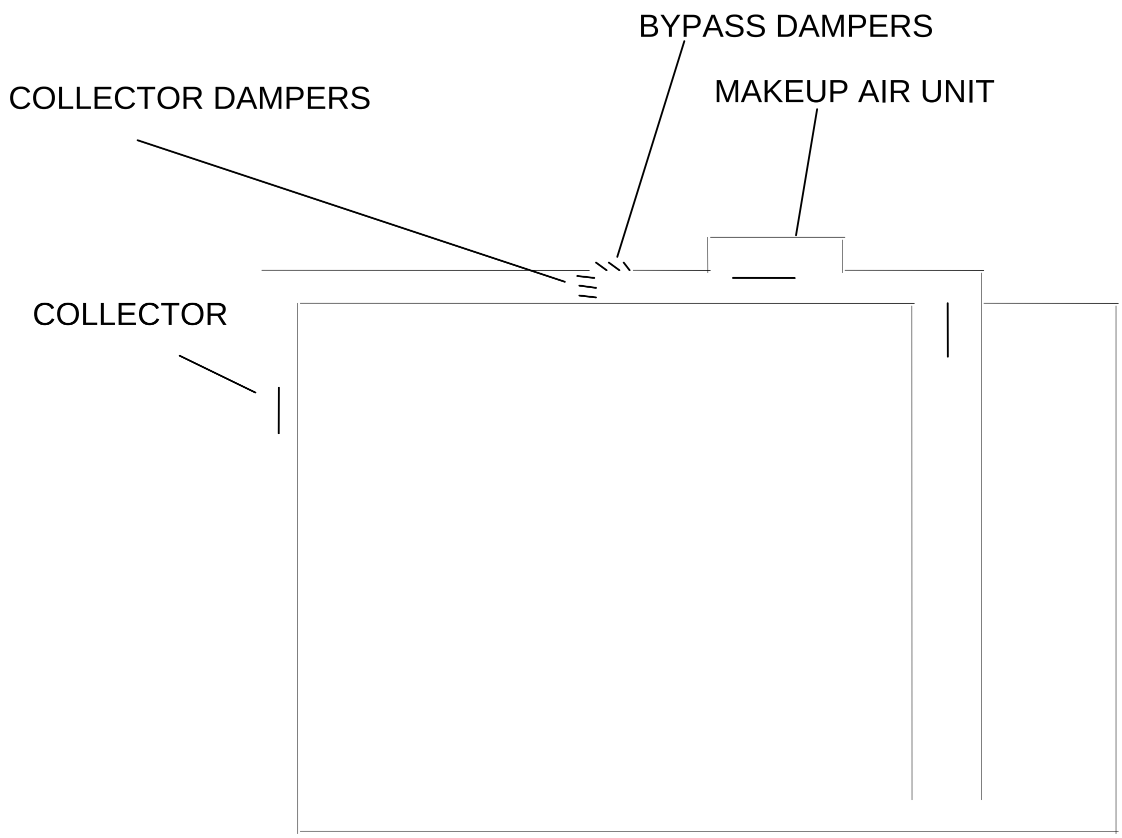


**Figure 5: System Schematic**

It may be desirable to modify the supply temperature setpoint between summer and winter. For example, in summer, when heat is not needed, a lower setpoint allows the ventilation system to be used for free cooling of the building. In winter, a higher setpoint, as high as comfort in the corridors will allow, provides an opportunity for the solar preheater to meet some of the space heating needs of the building itself, as hot air is introduced into the corridors and subsequently can make its way into heated spaces.

Most makeup air heating systems have built-in heater modulation capability and will automatically respond to the varying temperatures provided by the solar preheater. In a study of different heater types, gas-fired, makeup-air heaters with modulating burners were found to provide the best control. Hydronic heaters can work well, but controls need to be carefully programmed and commissioned in order to avoid hunting and other problems. Electric heaters should be avoided, due to the cost of electric heat, and because they have been found to be unreliable, with heater elements that burn out.

During commissioning of the system (see Figure 5), operation of the two systems (solar preheater and makeup air heater) operating in tandem should be checked to make sure that any problems with a makeup air heater are not blamed on the new solar preheater.

An advanced control algorithm could be considered to measure whether there are ever any conditions where the air leaving the collector is colder than the outdoor air. In other words, it would indicate whether the collector has caused radiative cooling of the air (for example, to a clear night sky). In these cases, the collector also should be bypassed.

The ideal makeup air control sequence should shut the system entirely when the outdoor air temperature is below the winter design temperature, should modulate its heat output to maintain 70 F supply air when the outdoor temperature is between the winter design temperature and 70 F, and should shut the heater (but not the fan) when the outdoor temperature is above 70 F. Conversely, if there is air conditioning of the makeup air, the air conditioning (but not the fan) should be locked out below 74 F outdoor air temperature, the system should modulate (if possible) above 74 F, and the entire system should be locked out above the summer design outdoor air temperature.

## Bid Phase

There are few contractors in New York State with experience installing the ventilation solar preheater. However, the technology is simple enough to be installed by any qualified general or mechanical contractor. Encourage discussion between the contractors and the manufacturer during the bid phase, allowing sufficient time for the contractors to familiarize themselves with the technology, to avoid over-bidding due to lack of familiarity with the solar preheater. By way of reference, the Syracuse demonstration installation (nine stories high, with 1080 square feet of solar collector) was installed by a crew of two people in approximately two weeks, with the main collector completely installed in five days, and five days needed for ductwork and controls.

Taitem estimates that an appropriate budget for this system includes a fixed cost of $9,000 to $13,5000 per wall exposure, plus $12 - $19 per square foot of collector area and $180 to $275 per linear foot of ductwork. We anticipate that the price will be lower if the work is done as part of a new construction project and if the contractor is familiar with the system.

The photographs on the following page illustrate the installation process.

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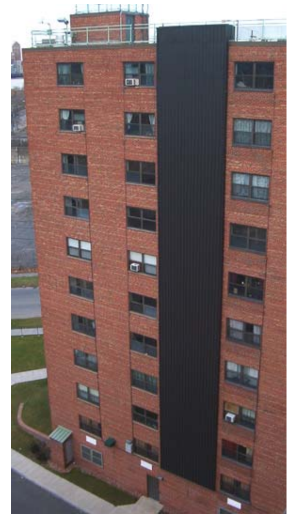
Installing the framing


Installing the cladding


Finished appearance

### Commissioning

Commissioning of a solar preheat system is important and should include:

(a) Visual inspection of the collector system to ensure there are no gaps in the sides, top and plenum, or bottom, which would allow bypassing the collector face.

(b) Ensuring smooth operation of the dampers.

(c) Measurement of the mixed collector/bypass temperature to ensure that the damper control is working correctly.

(d) Measurement of the makeup air supply temperature to ensure that the makeup air system is operating correctly.

(e) Measurement of the overall supply airflow rate.

(f) Measurement of leakage of dampers.

(g) Visual inspection of duct insulation to ensure that it is secure.

This Technical Topic was developed in the course of a research project conducted by Taitem Engineering for NYSERDA's Buildings Group. Further information is available in a Final Report; contact Ian Shapiro at imshapiro@taitem.com.

This information is provided for the Technical Topics discussion in February 2009