Solar collector system for heating ventilation air

Summary
The Conserval Perforated Plate Solarwall is a metal solar collector designed to provide preheated ventilation (make-up) air for buildings. The system is intended primarily for industrial applications, but also has potential for commercial and multi-residential buildings with large south-facing walls.

In 1991, a 420 m² Solarwall was erected at the General Motors of Canada Battery Plant in Oshawa, Ontario. This installation reduced energy costs in several ways: by capturing solar energy, by reducing heat loss through the south-facing wall of the building, and by destratifying indoor air.

The cost-effectiveness of the Solarwall measured relative to the available alternative make-up air systems gave a payback period of one year.

Highlights
• Highly efficient solar air heating system
• Performs better than glazed walls, yet costs less
• Short payback compared to alternative systems

Solarwall at GM Battery Plant.
Aim of the Project

The Conserval Perforated Plate Solarwall is an aesthetically pleasing solar collector designed to provide preheated ventilation (make-up) air. It can be retrofitted to an existing wall without the use of expensive glazing. The project aimed to show that the Solarwall could operate effectively and economically at the General Motors plant.

The Principle

In the past, industrial solar air heating systems have often involved the addition of large, glazed facades on the exterior of south-facing walls. Unfortunately, these glazed walls raised fire concerns, were expensive, and were sometimes unsightly. Moreover, some incoming solar energy was lost due to reflection from the glazed surface.

The Solarwall is a solar air heating system that addresses these problems. The complete system consists of four main components: a perforated metal collector (the Solarwall), a canopy overhanging the Solarwall, fans, and ducting inside the building for air distribution.

The Solarwall is an unglazed aluminium surface perforated by small holes. This aluminium surface is mounted on the south-facing exterior of a building, separated from the main building wall by an air space. To maximize the absorption of solar energy, the aluminium surface is painted black (although any dark colour can be used). As outside air is drawn through the perforations and into the air space, the absorbed solar heat is transferred from the metal to the air.

In the air space behind the aluminium surface, the warmed air rises, partly by convection and partly due to the action of the fans. At the top of the wall, the air enters the canopy, which extends horizontally across the top of the wall. Inside the canopy, the air moves towards the intake openings, where it is drawn into the building.

Like the metal wall, the canopy face is perforated. In addition, the underside of the canopy, which overhangs the wall below, is perforated to collect heated air rising up the outside face of the Solarwall.

Inside the building, the fan system is coupled to perforated fabric ducts that direct the make-up air to those areas of the building that require ventilation. A set of dampers controls the mixture of fresh solar-heated outside air with recirculated plant air.

To assist in destratification of the indoor air, the ducts are located at ceiling level. Because the air supplied by the system is cooler than the air at the ceiling, the delivered air settles towards the floor, causing mixing of the building air.

The Situation

In the summer of 1991, a Solarwall was erected at the General Motors of Canada Battery Plant in Oshawa, Ontario. The Solarwall has a total area of 420 m², including 365 m² of vertical perforated plate. The metal is perforated with a regular pattern of small holes 1.6 mm in diameter. In total, the holes make up about 2% of the wall surface. The Solarwall is separated from the existing wall by an air space of about 150 mm.

The canopy has a cross-sectional area of 1.6 m². It projects outwards beyond the surface of the wall below by 900 mm. The face and
underside of the canopy are perforated, with the openings making up 1% of the surface area.

Air is drawn through the wall perforations into the air space by two high efficiency vane-axial fans. The maximum design flow rate is 74,700 m³ per hour, delivered to the plant via 122 m of perforated fabric ducting. Actual airflow rates are approximately 68,000 m³ per hour.

The temperature of the delivered air is controlled by mixing solar heated air with recirculated indoor air: the lower the temperature of the air from the collector, the greater the proportion of recirculated air. The desired air delivery temperature is preset and controlled automatically. Selecting the lowest comfortable temperature maximizes the active solar performance of the system.

When the outside temperature is above 18°C, the system is designed to bypass the Solarwall completely. Automatic dampers in the canopy allow air to be drawn directly from the building exterior.

The Solarwall is nearly maintenance-free, and the fans, motors, and dampers require only a few hours of maintenance each year. The ducts have a life expectancy of 20 years and the Solarwall itself has a near indefinite life (since it is constructed of aluminium).

Based on 1993-94 monitoring results, the GM Solarwall is delivering 455 kWh/m² of solar energy per year, at an average solar collection efficiency of 72%. In addition, the Solarwall system reduces heat transmission through the south-facing building wall, recovers lost heat in the incoming air and destratifies the indoor air. The most recent monitoring results show that these savings amount to 300 kWh/m² annually. Thus, the GM Solarwall is contributing an estimated annual total of 755 kWh m² of collector area (based on an eight month heating season).

**The Company**

Conserval Engineering Inc. of Toronto, Canada has been designing solar air preheating systems since 1982. Conserval initially developed glazed and unperforated Solarwall systems, then refined their approach with the development of perforated systems. This technology served as Canada’s official contribution to the International Energy Agency’s Solar Heating and Cooling programme, Annex 14: Advanced Active Solar Energy Systems.

**Economics**

The total cost of supplying and installing the Perforated Plate Solarwall system at the General Motors plant was about CAD 92,000, or roughly CAD 220 m². Costs per square metre can be expected to be lower for larger systems and for

| Incremental capital cost to install the Solarwall | CAD 15,500 | CAD 23,200 |
| Annual energy cost savings provided by the Solarwall | CAD 12,200 | CAD 4,700 |
| Simple payback period (incremental capital cost - annual energy savings) | 1.3 years | 4.9 years |

The energy cost savings are based on steam costs of CAD 9.27 per 453 kg (1000 pounds), and gas costs averaging CAD 0.15/m³. For steam-operated units, total cost savings include an estimated CAD 1990 in reduced electricity costs for fan operation. (No savings in fan operation would be expected relative to the gas-fired units.)

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Table 1: Cost-effectiveness of the GM Perforated Plate Solarwall.
new construction (as opposed to a retrofit like the GM plant).

The cost-effectiveness of the Solarwall must be measured relative to the available alternative make-up air systems. For the GM plant, the available alternatives were a low pressure steam-operated fan coil unit, or a direct-fired natural gas unit. As shown in table 1, capital costs for either system are lower than for the Solarwall system. However, the substantial energy cost savings generated by the Solarwall offset this initial cost premium.