Choosing an Open Roof Greenhouse

With their many benefits, deciding to use an open-roof structure is easy, but choosing the right system can be a challenge.

By Sven E. Svenson

One of the main advantages of a retractable roof system is that the size of the structure is not limited by the restrictive capacity of mechanical ventilation systems. This allows the total growing area to have fewer "edges," resulting in a more uniform growth response from the entire crop. Originally designed for snow protection of forest seedlings in the 1970s, retractable roof systems are now used for all types of horticultural production, with five types to choose from.

TYPES OF SYSTEMS

Open-panel Systems. Structures that use the entire greenhouse roof like a ridge-vent are available in standard greenhouse sizes. These "open-panel" structures are typically hinged at the gutters, allowing the glass, rigid-panel or double-poly glazings to be raised to a vertical position. One design has hinges at the roof ridge and one gutter, using a rack-and-pinion system to open the roof by closing the peaks like an accordion. A twin-peak design reduces the height of the panels, minimizing exposure to the wind.

Although they do not use a retractable plastic film, these structures do provide almost the same amount of roof ventilation as other retractable roof systems. open-panel systems require 4-15 minutes to open using a rack-and-pinion system, and individual sections can be left closed if needed. When closed, the structure functions similar to a covered greenhouse with typical heating and cooling requirements and typical snow and wind loads. For additional light and cooling control, a retractable shading system can be installed above or within the open-roof structure.

Open-panel systems are generally the most expensive of the "open roof" designs. A less expensive option uses double-poly film glazing instead of rigid panels or glass, but regular replacement of the poly film would be required.

Most of the open-panel designs do not use side wall ventilation, which severely limits their natural ventilation. With roll-up side walls, open-panel systems would provide nearly the same amount of total ventilation that is available from other types of retractable roof designs.

Long term wear on hinges and rack-and-pinion drivers are one concern with open-panel designs. Also, if the glazing is plastic, it may need to be UV-treated on both sides (not just the top). When the roof is open, both the undersides of the roof panels and the inside of the side wall glazing is exposed to UV light, which may reduce the longevity of the glazing. Common to all retractable-roof designs, the ability of a particular open-panel system to operate in wind, snow and ice storms needs to be studied based on local weather patterns. Like many other retractable roof designs, individual motors can operate several greenhouse bays (over 1/2-acre per motor). open-panel systems are presently the only retractable roof design that is compatible with the use of glass as the glazing material.

Retractable-Film Systems. "Retractable-film" structure are the namesake "retractable" roof systems and are typically mid-range in price. Cost per unit area falls as the total amount of area installed increases.

Peak-roof film systems that "fold" the glazing as the glazing is retracted are available in standard greenhouse widths from 20-48 feet, and custom widths can also be designed. With the ➧

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roof closed, the structures are typically engineered to handle snowloads of 20-40 pounds per square foot and wind loads of 100 miles per hour, and additional load strengths are available. In the early and late 1990s, some growers purchased untested designs that had insufficient wind resistance; the structures failed during storms. Purchase systems that have already proven themselves under grower conditions.

When open, retractable-film systems provide over 95 percent ventilation. Only the rolling-roof systems can compete with retractable-film systems for total amount of natural ventilation. With the roof closed, the structures are over 98 percent airtight (properly designed and installed) and provide from 18-65 percent shade. Other shading levels are available. End and side walls are often covered with single-layer polycarbonate or with roll-up sides (preferred).

Without internal energy curtains, most retractable-film structures have heating costs similar to the same-sized structure covered with a single layer of corrugated polycarbonate. Energy curtains, which can double as an additional layer of shading or as black-out cloth for photoperiod control, greatly improve the heating efficiency of the structures.

The roof and roll-up side wall coverings are typically made from a woven polyethylene, with a protective coating on both sides along with anti-fog and anti-condensate coating on the underside. The plastic film glazing is suspended from hooks that slide along heavy-gauge, stainless steel wires. Make sure the design you purchase uses wires and an installation process that prevents the wires from "stretching" after installation. A central motor and drive-shaft pull the covering from truss to truss. A single motor can operate up to five 10-meter-wide bays with a maximum length of about 88 meters. The roof can retract or close in 2-3 minutes. Life expectancy of the covering is typically 10 years, but may only have a 5-year guarantee. To operate bays independently, individual motors are needed for each bay (increased installation cost). One manufacturer uses an internal gutter design to help prevent snow or ice "flooding" of gutters that can damage structures and the crops inside.

Although originally designed with solid side walls, the majority of retractable-film designs are now built with seasonally removed or roll-up side walls (motorized or hand-crank). Using motorized and automated side walls allows the structure to be ventilated in a controlled manner and improves crop uniformity.

Long-term wear on drive lines, pulleys and cables, or rack-and-pinion systems are one concern with retractable-film designs. Unlike open-panel systems, the underside of the glazing of retractable-film systems are rarely exposed to UV-light, but side wall glazing may be ➧

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exposed to UV-light on both sides. Common to all open-roof designs, the ability of a particular retractable-film system to operate in wind, snow and ice storms needs to be studied based on local weather patterns. Like open-panel designs, individual motors can operate several greenhouse bays (over 1/2-hectare per motor).

Open-panel designs allow direct sunlight to reach the crop only during hours near mid-day (when you often need to shade to control heat), but retractable-film and rolling-roof systems can be operated to allow direct sunlight to reach the crop throughout the day. Unlike open-panel or rolling-roof systems, there is some concern about the removal and installation of the glazing when the glazing has aged beyond usefulness. Both retractable-film and open-panel designs can be easily fitted with internal "black-out" curtains for photoperiod control, along with any equipment normally used in stationary roof greenhouses.

Flat-Roof Systems. A third type of retractable roof system, the "flat-roof" system, is very similar to retractable-film systems, but they have two major differences.

First, flat-roof systems do not have trusses, which significantly reduces structural, installation and glazing materials costs. Second, the glazing is typically designed to allow water to pass through.

Crops that are not tolerant to rainfall, or cannot weather exposure to snow or ice storms should not be grown in flat-roof systems. Rainwater drips through the glazing, or the glazing is retracted to allow rainfall to naturally irrigate crops. The glazing is usually retracted during heavy wind, snow or ice storms, or during severe wind storms, to prevent damage to the structure. In this way, severe storms that destroy stationary roof structures and some retractable roof designs can be "survived" by the retractable or roll-up roof systems.

Crops grown in small container sizes are not normally produced in flat-roof retractable systems. The water dripping through the film during heavy rains can wash-out seedlings or plants in smaller cells.

Flat-roof systems are typically used as shading systems during spring, summer and fall, and for unheated or heated cold protection during fall, winter and spring. They can also be used as on-demand protection from hail, wind or short-duration ice storms. Compared to outdoor growing areas, flat-roof systems provide a year-round "protected" growing compound. Crops are protected from unexpected or unseasonal winds, cold, frost, freeze, heat and other short-term weather patterns that can destroy unprotected crops.

Properly managed, the flat-roof systems can be used for "heat-trapping" or "cold-trapping" to regulate crop development. Open-panel and retractable-film structures are less effective for cold-trapping but may be able to use cold-trapping if equipped with energy curtains.

Some nurseries have started installing flat retractable roofs with two layers of glazing. One glazing layer is used for shading or cold protection (often a white woven film with a shading factor of about 50 percent), while the ➧

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other is used for light transmission and heat retention (often a clear IR woven film with a shading factor of about 20 percent). The combination provides two layers for cold protection, two layers for heat retention and summer shading at two different levels. The grower obtains the ability to force the crop with heat retention, slow the crop with cooler temperatures or manipulate development with DIF (the difference between the day and night temperature). Flat-roof systems have been installed as "blackout" compounds to protect container-grown forest seedlings from long photoperiods.

Without trusses, flat-roof systems may not be compatible with all types of greenhouse automation equipment, or installation adjustments may be needed to use automation equipment. For example, boom irrigation systems cannot hang, so they must be mounted to side wall posts.

Low-Profile Systems. These are either very wide-span systems with low-pitch roofs, or they may have sawtooth-style roofs. The low-pitch roofs often use specialized film glazings that contain hundreds of small channels that direct rainfall or melted precipitation to the gutters. They typically require the use of expensive energy-trusses to design them for reasonable wind and snow loads. Their ventilation can be as good as retractable-film systems if proper side wall ventilation is installed.

Aside from snow and hail loading, the main concern with low-pitch roofs for the low-profile design is the "failure" of the channels in the glazing. In some situations, condensation and algae growth in the glazing channels have contributed to reduced light transmission. Other concerns would be similar to open-panel or retractable-film systems. The main advantage of low-pitch roofs is the limited number of posts required to support the roof, which may improve labor efficiency inside the structure. However, since many automated systems are designed for structures of typical post spacings, the low-pitch roof may have limitations related to customized accessories. Depending on the strength of the trusses, low-profile systems may not be compatible with all types of greenhouse automation equipment, or installation adjustments may be needed to use automation equipment in a manner similar to that of flat-roof systems.

Sawtooth retractables are a hybrid of stationary sawtooth-greenhouse designs and retractable-film systems. The short wall above the gutter can be rolled up to provide ventilation similar to a "typical" sawtooth structure (standard saw-tooth operational procedures), which allows roof ventilation with less risk of precipitation landing on crop foliage. This is the main advantage of this design, and it is the only open-roof system that provides for roof ventilation without risk of allowing precipitation to reach the crop. The entire roof glazing can be retracted to provide complete ventilation and crop exposure, if needed. Retractable ➧

Regardless of type, all open-roof greenhouses provide natural ventilation, better light quality and in-place hardening.

sawtooth systems are very versatile but are usually more expensive than most other retractable roof systems. The mechanical wear concerns are similar to other open-roof systems.

Rolling-roof Systems. The rolling-roof is perhaps the oldest design concept in use. One of the earliest automated open-roof systems used for "seedling" production in the 1980s was a rolling-roof design (Northwest Transplants, Woodburn, Ore.). Growers have been using hand-crank, roll-up roofs on hoop or quonset structures for decades.

Flat- and peaked-roof systems that "roll" film plastic glazings are available in standard greenhouse widths from 5-10 meters, and custom widths can also be designed. Most rolling structures have peaked or quonset (igloo) roofs. Ventilation capacity can be as good as retractable-film systems.

Rolling-roof structures typically have bows mounted on lattice trusses spanning each bay. Tube-type motors drive aluminum pipes that roll the covering up or down on each side of the bow. The film glazing is usually rolled up from the gutter toward the ridge. Each bay can be up to 300 feet long and is operated independently using four motors (sometimes only two tube motors have been used). The roof can be retracted or closed in 2-7 minutes.

The covering is typically a nylon mesh film enclosed within two layers of plastic, with a life expectancy of 4-6 years. The covering provides from 15-25 percent shade when closed. Less-expensive coverings can also be used with more frequent replacement.

Rolling-roof end walls are typically covered with single- or double-layered polycarbonate, and roll-ups are often used as side walls when gutter-connected structures are installed. Along with flat-roof systems, rolling-roof structures are often much lower in price compared to other designs. However, rolling-roof systems require a large number of motors that require more wiring if full automation is desired.

Durability of motors and physical stress on the glazing are concerns with rolling-roof designs. The glazing may need to be UV-treated on both sides (not just the top). When the glazing is being rolled, the undersides may be exposed to UV light, which may reduce the longevity of the plastic.

Common to all open-roof designs, the ability of a particular rolling-roof system to operate in wind, snow and ice storms needs to be studied based on local weather patterns. Depending on the design, rainfall or overhead irrigation water can be "dammed" behind the pull bar, which then pours down onto the crop when the glazing is lowered. The 'spill' water can wash-out seedlings or plants in smaller cells.

When the rolling-roof is designed to roll the film glazing

downward from the peak toward the gutter, there is less risk of forming "spill" water on the glazing. However, if ventilation is needed mid-day, plants would be subject to direct sunlight under conditions when shading may be required.

Depending upon the load strength of the bows, rolling-roof systems may or may not be compatible with typical greenhouse automation equipment.

ADDITIONAL EQUIPMENT

Roll-up Side Walls. Roll-up side walls greatly improve the growing environment produced by retractable-roof systems and can reduce labor costs. Some growers are so impressed by the improved plant growth provided by roll-up side walls, they are removing the solid plastic and glass side walls from their existing greenhouses and retrofitting them with roll-up side walls. Side wall retrofits have already been completed at bedding plant, perennial and forest seedling facilities in Oregon and Washington.

Computer Assisted Growing. A computer operation system is an essential component for proper operation of a retractable-roof system. Trying to keep the roof and side walls in the correct position by hand is a full-time job, and other chores will usually cause the worker in charge of the structure to "fail" on a regular basis. A one-time purchase of a good computer control system is much less expensive than a permanent, full-time worker.

Automation does not replace the need for you to operate your retractable-roof system. Remember that the computer only assists the grower in operating the system or growing the crop. These are "computer-assisted growing systems," not computer-controlled systems. Growers must know crop requirements and must make routine or seasonal adjustments to the computer settings as needed.

Automation Equipment. Generally, retractable-roof systems are compatible with all types of automation used in common greenhouse systems, but certain types of automation may not be compatible will all designs. Irrigation booms, monorail systems and rolling benches are commonly installed in retractable-roof greenhouses.

Before purchasing a retractable-roof system, visit with growers who are already successfully producing crops using the systems you are considering. GPN

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