

Avalon Discovery 3 Passive Solar Design

Avalon Discovery 3 is a new, one and one-half-story, 244 m² (2,624 sq. ft.), detached home on a residential lot in a new suburban community in Red Deer, Alberta. As a winning project in the CMHC EQuilibrium™ Sustainable Housing Demonstration Initiative, the builder Avalon Master Builder, designed and constructed this home with the intent that it is healthy and comfortable to live in, reduces energy use to a minimum, produces as much energy as it requires in a year, conserves resources, has low environmental impact, and is marketable. One of the key features that is helping to reduce the consumption of non-renewable energy, which is highlighted in this EQuilibrium™ InSight is the use of passive solar design principles.

Technical Specifications

Passive solar design involves maximising the amount of solar energy that can be effectively utilized for heating, while minimizing overheating. Simple steps such as orienting a house's main fenestrated façade towards south can make a big difference in reducing annual energy consumption for space conditioning. Passive solar features utilized in the Avalon Discovery 3 house are described below.

Site and Landscape Features

The house is positioned on a south-facing corner lot and oriented with an east-west axis, ensuring good solar exposure. The north side of the house is sheltered by the adjacent residential building.

Space Planning and Building Form

The south facing rooms in the house, including living room, foyer, kitchen and dining room, are all part of an open concept floor plan allowing for good circulation of air, heat, and natural light. The elongated east-west floor plan provides more south-facing areas than a square floor plan.

The design also includes a front covered entryway on the south façade, seen in Figure 1 below the dormer.

This space had a number of benefits:



Figure 1 South Façade of Avalon Discovery 3

- Creates storage space for coats, shoes, etc., that was not included in the open concept floor plan;
- Creates a 'buffer' zone or air lock chamber for the prevention of heat loss when opening the front door;
- Provides additional wall space for solar thermal panels on this south elevation; and,
- It is an aesthetically enhancing architectural feature.

To ensure adequate daylighting throughout the home, the design includes windows aligned with stairs and hallways, helping to bring sunlight deeper into the house.

Windows and Shading

The Discovery 3 team used triple-glazed argon-filled windows with two low-e coatings, and insulated spacers. The windows effective insulation value is of RSI-1.16 (R-4.8).

To limit overheating and provide a more stable indoor temperature, the team used carefully designed and positioned window areas. The total window area was 20.5 m², with 7.3 m² on the south façade, representing 3% of the heated floor area, and the remaining windows were spread relatively evenly on the other façades.

To further reduce overheating, and to add an extra insulating layer, exterior shutters were installed on all the windows. Exterior shutters offer a number of advantages over internal shading devices by:

- Not transferring heat absorbed by the shading device into the living space thus reducing the cooling load;
- Providing an added thermal break without increasing the risk of window condensation; and
- Providing an added security layer.

Thermal Mass and Passive Cooling

The high performance building envelope combined with the interior thermal mass (the concrete slab-on-grade), was designed by the Discovery 3 team to minimise interior temperature fluctuations. The thermal mass absorbs excess daytime solar heat and releases it at night when it is needed.

Operable windows were placed to take advantage of prevailing wind directions to help enhance natural cross ventilation.

Implementation Considerations

The Discovery 3 team encountered some issues with the implementation of the exterior roller shutters. Aesthetically, the shutter operators located inside the house were difficult to integrate with the interior decor (Figure 2). The team also had to contend with the control strap penetrating the wall as it was difficult to get a perfect seal at that location, and the most insulation they could get on the interior of the



Figure 2 Lever for Exterior Roller Shutter

header supporting the shutter assembly was RSI-1.8 (R-10). However, the shutters provide an overall net thermal benefit, since they add about RSI-0.5 (R-3) to the thermal resistance of the windows and help prevent overheating.

The Discovery 3 design team opted to reduce the risk of overheating and to provide a more stable temperature throughout the year by minimising window areas. To compensate for the reduced solar gains in the winter, the team designed a larger, more efficient, active solar system. Although an active solar system is more expensive, the team opted for this option given that they were going to be installing the system in any event as part of their net-zero energy strategy and decided that increasing the size, cost, and efficiency of the system would be worth the added thermal control.

Cost Implications

The Discovery 3 team estimates that the selected windows costs over a standard dual glazed window were moderate (about 25% in total). The reduced overall window areas used in the house helped compensate for cost of the better performing windows. The team considered higher performing, albeit more expensive, windows but instead opted to spend more on the exterior roller shutters to help improve the efficiency of the overall window system.

The overall cost of the roll-down shutters, including labour was about \$12,000, or roughly equal to the cost of the window package. However, the shutters can essentially eliminate solar gains, which reduces the need for an air-conditioning system.

The true benefit of the front entryway was difficult for the team to model for as it is dependent on the average traffic through the main entry of the home. However, the team felt that the cost of this feature could be justified on practical and aesthetic reasons alone.

Technology Benefits

Energy Savings

The energy efficiency features of the house reduced its heating energy requirements substantially compared to a standard house. The passive solar design of the home helps further offset annual space heating requirements by approximately 30% or 4,000 kWh. Internal gains provide an additional 27% of the heating load, which leaves only 5,750 kWh of heating energy required from the active solar system and back-up electric instantaneous heater.

Occupant Comfort

The design team's priority in developing its passive solar design strategies was to maintain thermal comfort throughout the year and to balance the benefits of solar energy in the winter against its cost in the summer. According to the team, the resulting design provides year round comfort with limited heating demand and no need for air conditioning.

The shutters are expected to add to occupant comfort by improving the windows' privacy, security, and sound deadening properties.

Summary

The Discovery 3 design team carefully balanced passive solar gains with improved occupant comfort. The resulting design achieves a 30% passive solar heating fraction with carefully designed and positioned windows that the team expects will provide occupants with a stable, comfortable, temperature throughout the year. One of the novel features that was utilized by the team as part of their passive solar design strategy was the use of exterior roller shutters. The added performance that these shutters bring to the complete window system helped the team avoid using more expensive but higher performing windows.

Project Team

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For more information about this project and other EQUilibrium™ housing projects, visit CMHC's website at www.cmhc.ca

EQUilibrium™

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