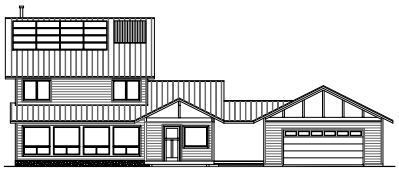
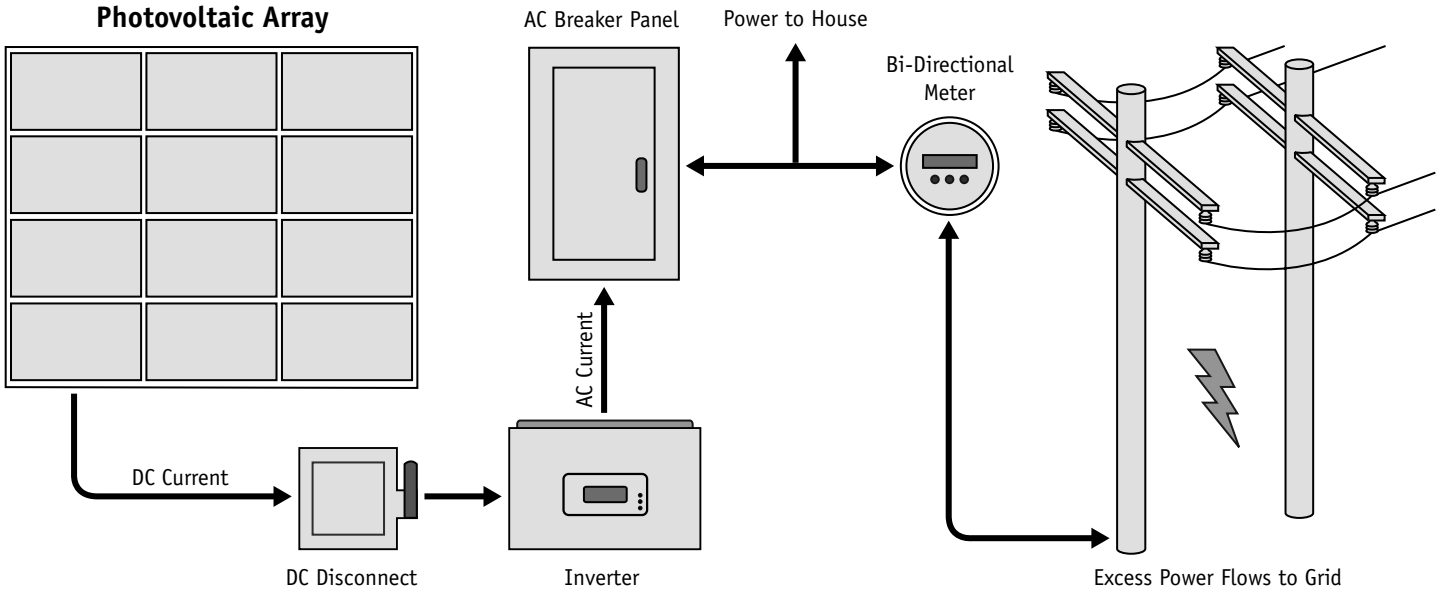
Eco-Home
at Hawk Ridge



A solar model demonstrating energy efficiency, renewable energy and green building

Schematic Diagram : Solar Electric System



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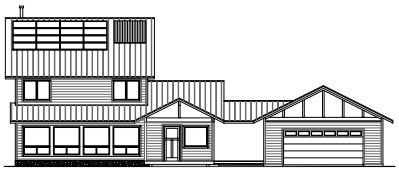

A solar model demonstrating energy efficiency, renewable energy and green building

Renewable Energy Systems

Besides being very efficient in its use of energy and harvesting the sun's energy directly through the windows, the Eco Home is equipped with three active renewable energy systems. A solar electric system turns sunlight directly into electricity which helps meet the home's electrical load. A solar hot water system heats water for showers, sinks and other uses. A wood stove in the living room allows for the use of our region's only source of stored renewable energy in the form of firewood as a fuel. Together these systems help reduce the need for imported fossil fuel energy and its environmental impacts.

Solar Electricity or Photovoltaics

The Eco Home has a 2-kilowatt solar electric system on the roof. The roof of the house was designed and built at a pitch that works well in our climate with solar technologies. In areas that don't get as much snow as we do here it is common to install solar panels flush on any roof. In snow country we cannot do that on a low pitch roof without losing several months of production when the panels are covered with snow. This system is "grid tied" with no on-site storage. The solar panels generate high voltage direct current electricity when the sun is shining and feed it into a device called an inverter in the mechanical room. The inverter changes it into 240-volt alternating current just like what the utility provides. It is fed into a breaker in the breaker panel and helps power the home's electrical loads. When the home is consuming more than the system is producing the rest is purchased as usual. If the system is producing more than is being consumed the extra is fed into the utility grid and the electrical meter records a credit. The system requires no maintenance. It simply turns on when the sun is shining and shut off at night. This system will produce, on average, over 3,100 kilowatt-hours of electricity a year which will keep over 5,600 pounds of CO2 out of the environment, by replacing some coal burning at a local power plant.

Solar Hot Water System

The second active renewable energy system in the home is a solar water heating system. Unlike photovoltaics, which convert sunlight into electricity without involving heat, the solar hot water system converts the suns rays directly into thermal energy to heat water. The energy is used to heat water in an 80 gallon tank, stored for use when needed. A collector on the roof, which holds sixteen evacuated tubes, will produce about 80% of the hot water used by 2-3 people. Evacuated tube collectors have a few advantages over the more common flat plate collector. They are able to perform a bit better in very cold weather, are easier to handle and install, and individual tubes can be replaced if ever needed without draining the system or removing the collector from the roof. A heat transfer fluid, consisting of water and antifreeze, moves the collected energy from the collector down to a double walled heat exchanger suspended in the bottom of the water storage tank. An electronic controller turns on a small pump when the collector temperature rises above the tank temperature by a few degrees and shuts it off when it cools down after the sun sets.

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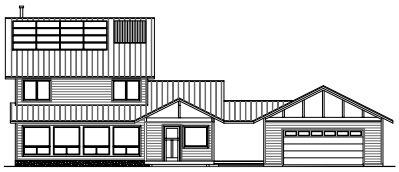

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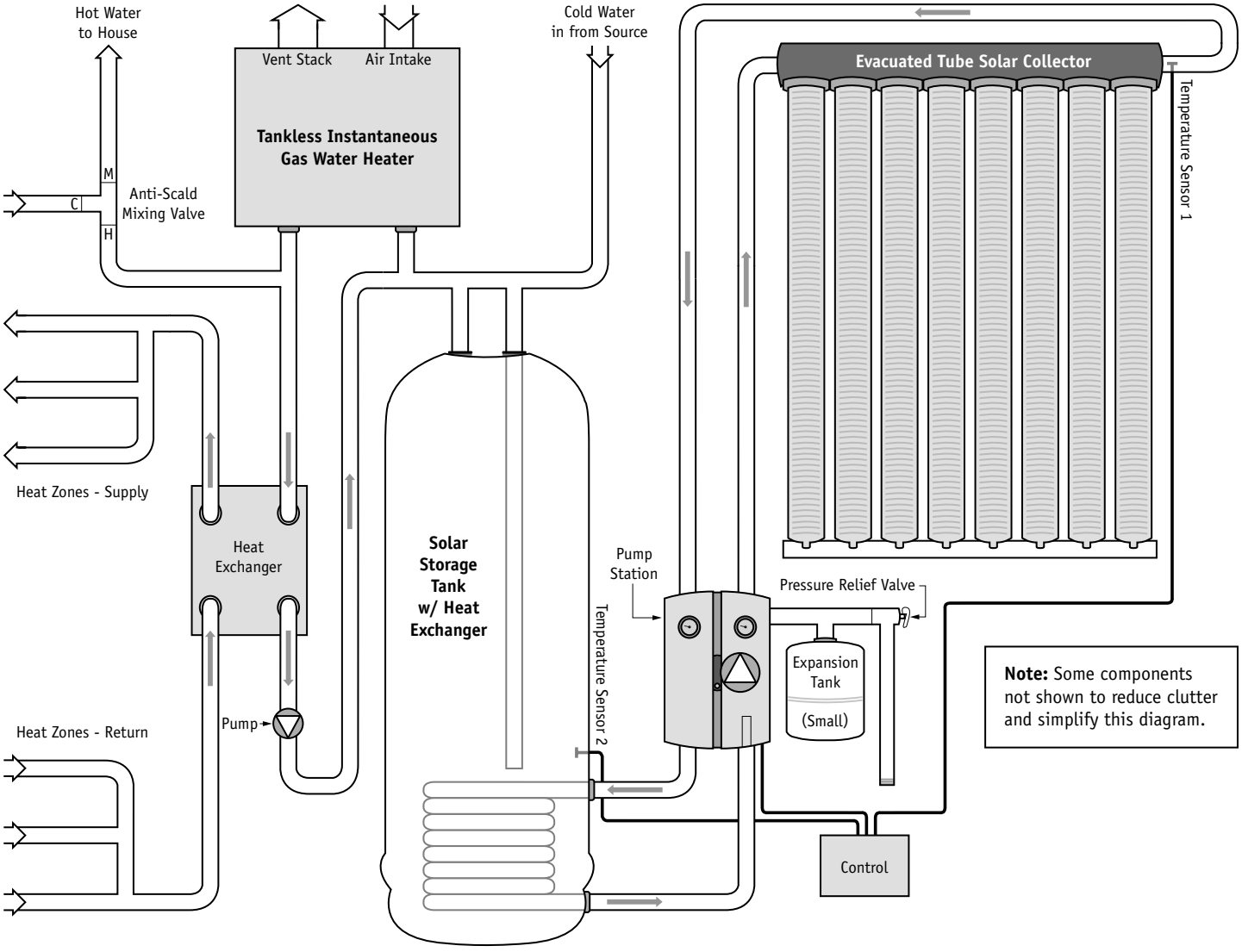
Schematic Diagram : Solar Hot Water System



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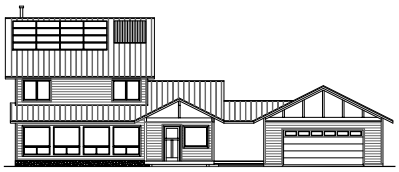

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Solar and Hybrid Mechanical Systems

The high-performance envelope design and detailing (including extensive energy calculation and analysis) resulted in a home with extremely low heating requirements. The estimated annual heating consumption of 25.4 million Btus is about a third of the energy that would be used in a house built to standard MN energy code. Typical residential heating systems are built to a peak design heating load of about 25-30 Btu/sf; the Eco-Home has a design heating load of 8 Btu/sf. This very low heating requirement led to an innovative heating system design responding to the conservation goals of the home.

The Eco-Home has a "hybrid" mechanical design, where an integrated system provides both heat and domestic hot water. It is a combination of very current technologies, high energy efficiencies, and renewable energy. It is a reliable whole house system; unusual in that it operates without a conventional boiler or furnace, but it uses technologies and operations that are easily understood.

The Domestic Hot Water / Heating Plant

A roof-mounted solar thermal array heats water in an 80-gallon storage tank by circulating a heat transfer fluid through a double walled heat exchanger in the bottom of the tank. As hot water is drawn from a faucet or shower the water temperature is boosted as needed by a natural gas on-demand water heater. The on-demand water heater thermostat is set to approx. 120 degrees F. When there is a need for hot water the water leaves the storage tank and runs through the on-demand heater. If the water is not as hot as the set temperature, the heater fires to "boost" the outgoing water to the required temperature. If the water in the tank is hot enough, the water heater shuts down and the water flows on through the distribution system. If the water in the tank is hotter than desired an anti-scald valve mixes in cold water to maintain a safe and comfortable temperature.

The Heat Distribution System

There are two heating zones in the home, each with a different distribution system. When heat is needed in one of the zones, a pump circulates water through the on demand heater and a double walled flat plate heat exchanger that transfers energy to the distribution system.

- **Zone 1** - In-floor hydronic radiant heat runs throughout the first floor slab, and also in the second floor bathroom.
- **Zone 2** - Warm air is heated with a water-to-air heat exchanger and circulated to the second floor bedrooms and study through the heat recovery ventilation system.

Local Renewable Stored Energy

A small wood stove in the living room provides additional space heating for the open areas of the first floor. The addition of space heat on the first floor provides a "quick heat" option when occupants want a faster response time than radiant floor heat typically provides. The wood stove alone is capable of heating the entire house.

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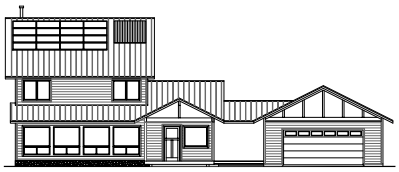

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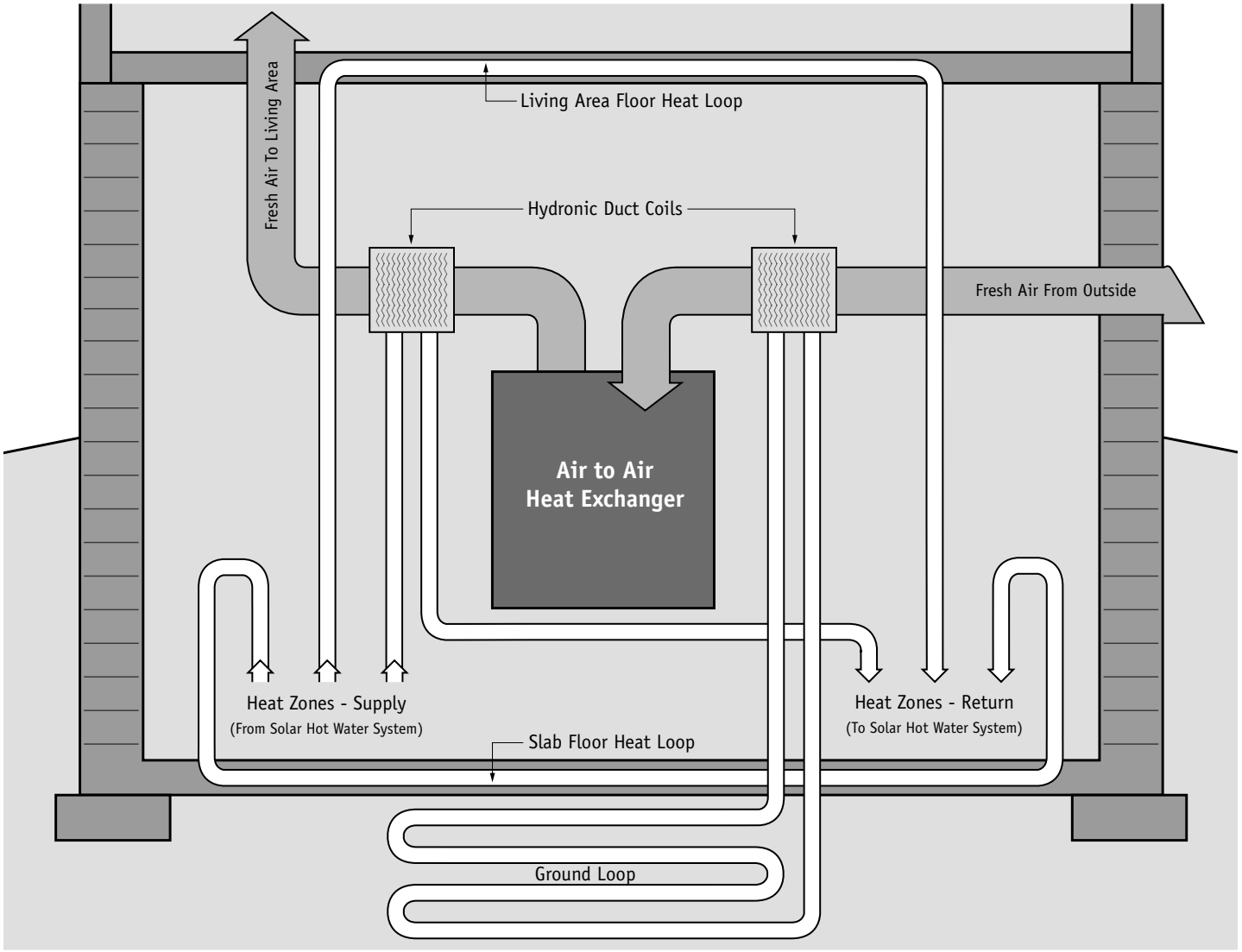
Schematic Diagram : Mechanical Ventilation Air Tempering



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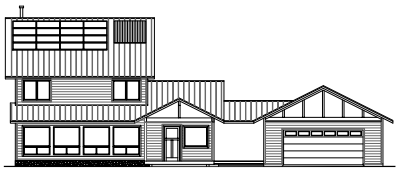

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Heat Recovery Ventilation

The Eco-Home is equipped with a high performance heat recovery ventilator. With higher than average heat recovery performance, and fitted with properly sized and distributed ducting, this system provides efficient and effective whole house ventilation. Beyond just ventilation, this system also incorporates experimental ground loop outside air tempering as well as a fresh air heating system that delivers heat to the upstairs bedrooms.

Basic Design Plus Innovations

The basic ventilation design removes stale air from the bathrooms and kitchen while delivering fresh outside air to bedrooms and living areas. This portion of the design represents a high performance fully ducted whole house system with close to 90% transfer of heat energy from the exhaust air to the fresh air in the winter. High speed override controls in the kitchen and baths eliminate the need for bath fans which, having no heat recovery, represent a significant energy loss by exhausting heated air directly to the outdoors.

Thanks to the high performance design of the home the heating loads are very small. This smaller demand opens the door to innovative approaches in heating and ventilation. The Eco-Home's ventilation system has a couple of added features.

The fresh air drawn into the house by the ventilation system passes through a washable filter and a finned coil before it enters the heat recover ventilator. The coil is connected to 250 feet of polyethylene pipe that is buried in the sand fill beneath 4" of foam insulation under the home's slab. This closed loop system is filled and pressurized with a water and antifreeze solution. A small pump circulates this heat transfer fluid through the loop and duct coil whenever the ventilator is running. The design is intended to provide a measure of tempering of the fresh air coming in from outside. This should help warm the air in the winter and provide a bit of cooling and dehumidification in the summer months. This ground tempering system is experimental and we hope to learn what potential there is in this approach by monitoring its performance and behavior during the years the home is open as a demonstration project.

The hybrid heating system provides heat to the radiant floor zones and also heats the ventilation air that is delivered to the upstairs. Different from a forced air system in that it usually uses all outside air, this low flow system will be no noisier than a normal ventilation system. To avoid over drying the house during very cold weather the system can switch to re-circulation mode for periods of time if needed. When heat is needed in the upstairs bedrooms a small circulator moves hot water through a second duct coil in the duct that delivers fresh air upstairs. Controlled by a thermostat this system will automatically deliver heated fresh air to the upper level.

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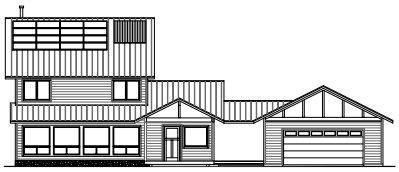

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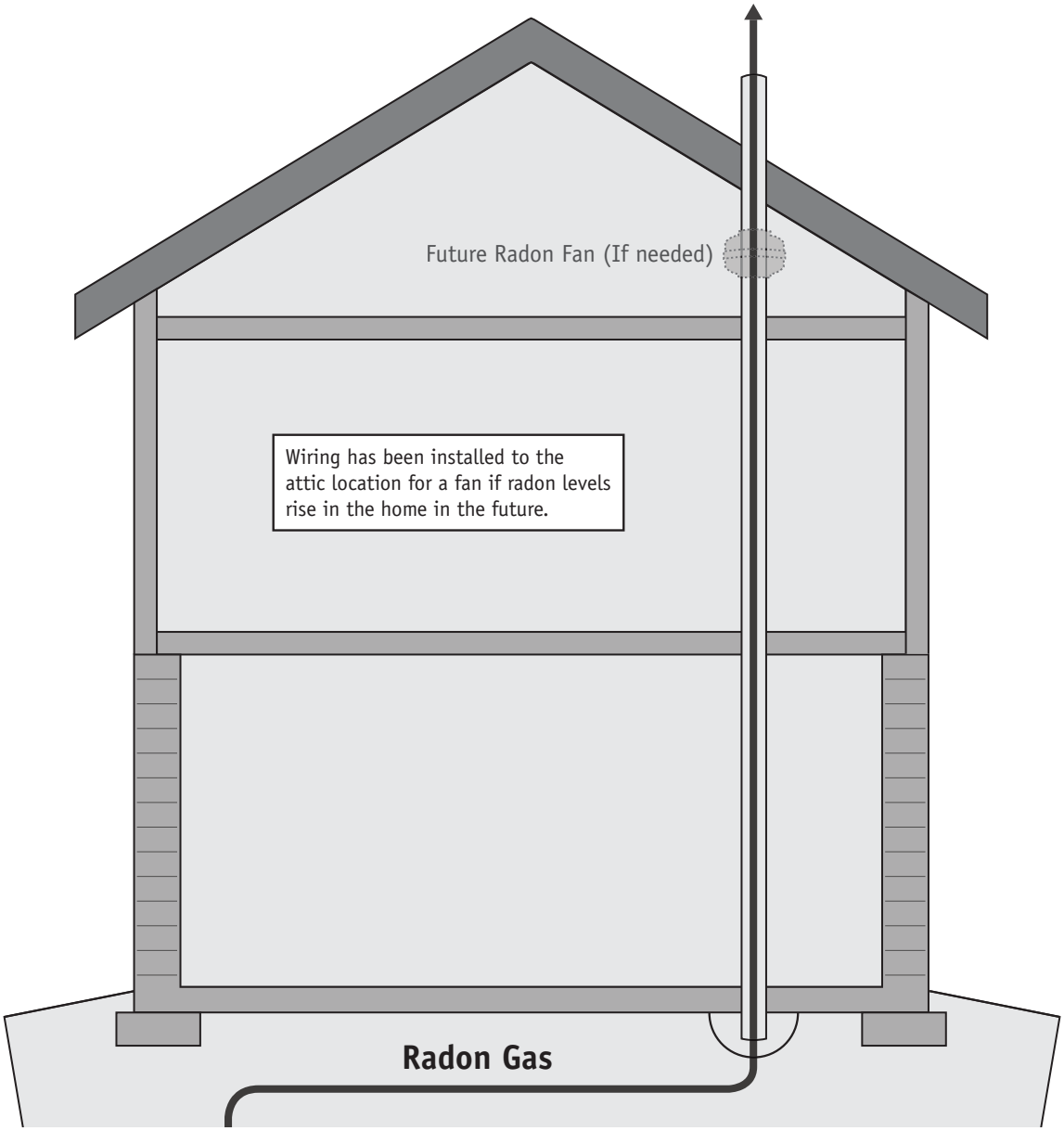
Schematic Diagram : Passive (Active Ready) Radon Mitigation System



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