GET OFF-GRID: HYDRONIC HEATING POWERED BY RENEWABLE ENERGY

ComfortHeat
Superior Floor Heating Systems

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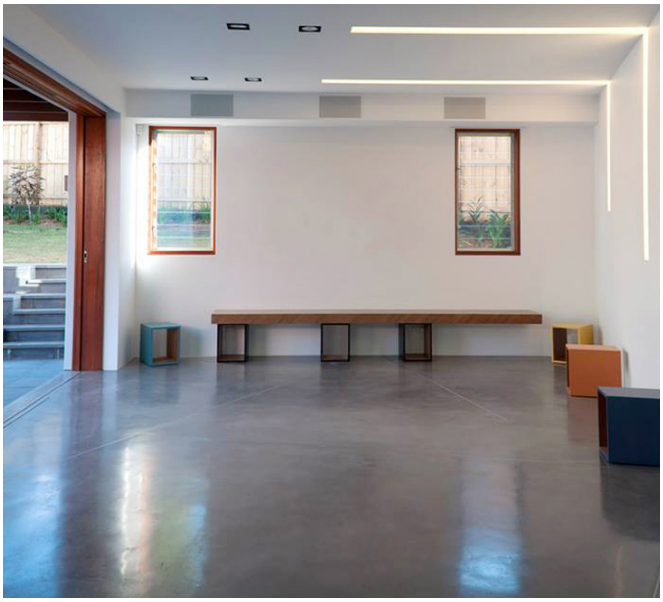
INTRODUCTION

Heating and cooling can account for 20 per cent to 50 per cent of energy use in Australian homes, depending on the climate zone.[1] With rising gas and electricity prices and concerns for the environment, there is an increasing number of homeowners who are choosing to live "off grid." Off-grid houses eliminate reliance on traditional utility services, such as gas and electricity; instead using renewable energy sources, such as sun and water, to heat and cool a home.

Hydronic floor heating is one of the most energy-efficient forms of heating, as well as one of the most thermally comfortable. Combined with passive solar design and high-density materials, hydronic floor heating is an effective and economical means of heating a house. The system can be powered by electricity generated from a photovoltaic solar array, and with hot water from a heat pump to provide efficient, renewable-energy heating in an off-grid house.

In this whitepaper, we examine how architects and specifiers can use hydronic floor heating in conjunction with high-density materials and passive solar design to optimise the efficiency and effectiveness of the hydronic heating. We also highlight how designers and specifiers can use hydronic heating with renewable-energy technologies, specifically heat pumps and photovoltaic systems, for homeowners who choose to live off grid.



UNDERSTANDING HYDRONIC HEATING

Water is the primary medium of a hydronic heating system. Water is considered an excellent conductor of heat because it has a high heat capacity (more than 4,000 times that of air), and thermal conductivity (25 times that of air).[2] This means it takes more energy to increase the temperature of water compared to other substances, which helps regulate the rate at which air changes temperature.[3]

A hydronic heating system warms the water at its source. For an off-grid house, the water can be heated in a number of ways using renewable energy sources:[4]

- slow-combustion wood fire stove or heater (wetback);
- solar panels or evacuated tubes (typically installed on the roof);
- geothermal pumps (utilising heat from the soil);
- air-sourced heat pumps (extracting heat from the air).

The heated water is piped around a building to heating panels, heating convectors or through the sub-floor using under-floor PEX pipes. In-slab hydronic floor heating pipes are embedded directly into the concrete slab. The pipes must be installed before the slab is poured or laid in a minimum 50 millimetres screed bed, after which the piping is covered by a concrete slab at least 30 millimetres thick. In-screed hydronic floor heating pipes are installed above the sub-floor in a minimum 50-millimetre-thick layer of concrete and can therefore be installed in both new and existing homes.[5]

As the water travels through the pipes, its heat energy is transferred into the concrete flooring, which emits heat into an interior space. This convective and radiant heat is why hydronic heating is comfortable, efficient and economical. It emits low, even and consistent heat with no blown air, and the slow release of heat energy from the water and concrete continues after the source has been turned off.

HYDRONIC HEATING AND THERMAL MASS

Hydronic heating systems leverage the thermal mass of concrete flooring to warm an interior space. Thermal mass is the ability of a material to absorb and store heat energy. High-density materials, such as concrete, have high thermal mass because, like water, a lot of heat energy is required to increase the temperature. Concrete flooring can therefore store heat during the day and release it at night to help a home stay warm and comfortable in winter. This heat can be generated from solar energy captured through windows or from hydronic floor heating.

A hydronic heating system, passive solar gains and thermal mass are complementary to each other and should be designed and installed in consideration of one another. Glazing and openings should be strategically placed and sized to maximise sun penetration throughout the day in winter for the benefits of thermal mass. As hydronic heating does not heat already warm floors, there is consequently no need to heat a floor where it is exposed to sun. The concrete already stores thermal energy, and the heated water in the hydronic system will pass by the already warm area to heat a colder section of the floor.

By delivering heat where and when it is needed, hydronic heating systems improve thermal comfort and reduce energy use. Thermostats detect when a room temperature becomes lower than the programmed target temperature, and zoned hydronic systems enable unoccupied rooms to be kept at lower temperatures, or where floors receive sufficient solar energy throughout the day.

A heated concrete slab will only store and radiate heat effectively if there is proper insulation to block heat energy from moving down into the soil, and if there is no air leakage through gaps around the perimeter. This will improve heat consistency in the interior space, reducing temperature swings and responding quicker to thermostat settings.[6] Insulative materials should be waterproof, thick enough and extend deep enough to decouple the concrete slab from the ground and keep the heat radiating upwards into the home. It should also extend beyond the edges of the floor slab, as approximately 80 per cent of heat loss from a concrete floor slab is at the edge where it is the shortest distance to the external air.[7]

COMBINING HYDRONIC HEATING WITH A HEAT PUMP AND PHOTOVOLTAIC SYSTEM

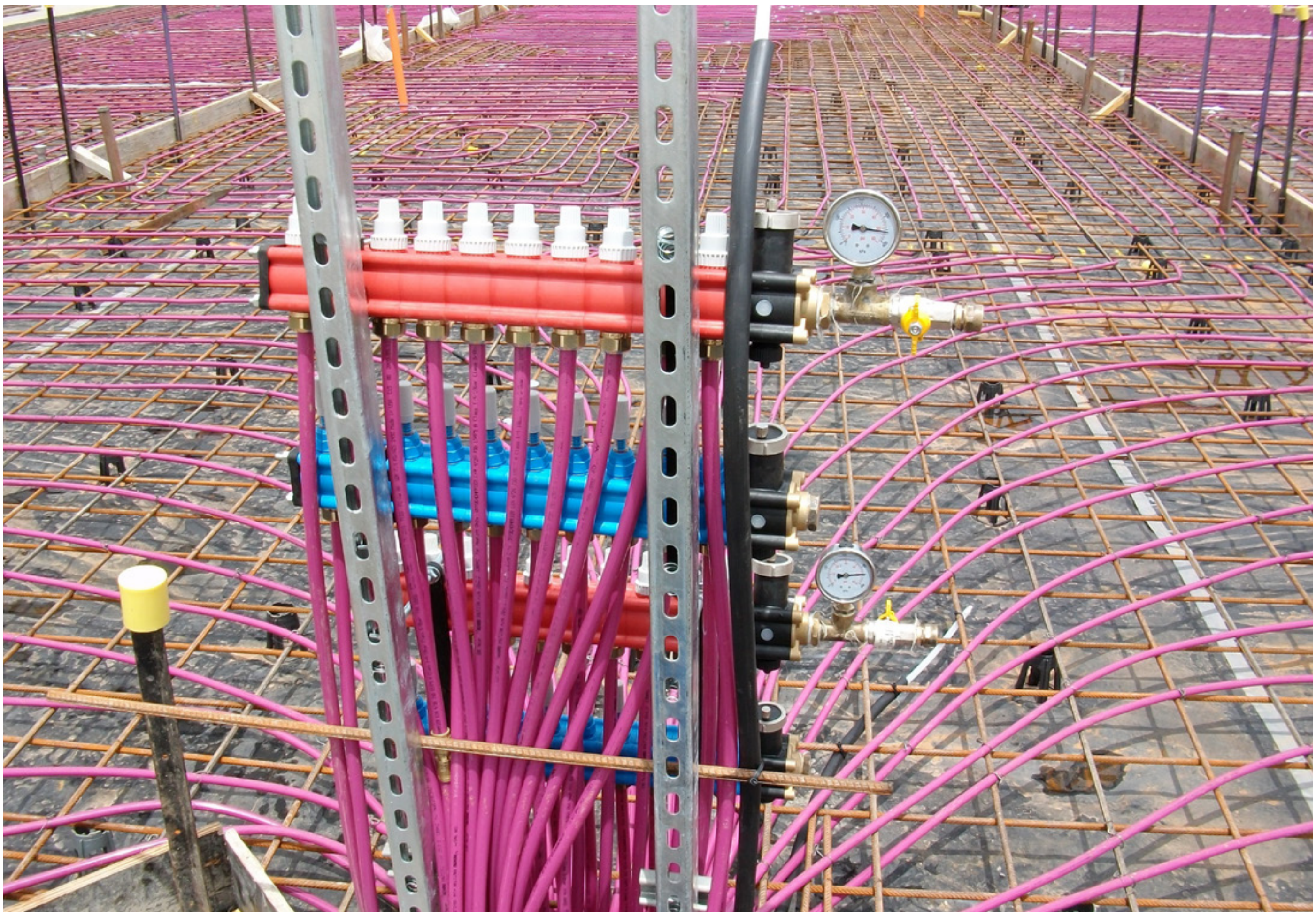
For an off-grid house, the most energy efficient and environmentally friendly heating system is combining hydronic heating with an air-to-water heat pump and photovoltaic array, which use renewable energy sources.

Hot water makes up approximately 20 per cent of energy costs of an average Australian household.[8] Heat pumps are an energy efficient means of heating the water at the source of a hydronic heating system. Heat pumps use a heat exchange system to extract heat in the air outside the unit and transfer it to the water circulating through the floor. Using a heat pump with a hydronic heating system provides heating for a quarter of the energy expended. Heat pumps can provide 4kW of heat load for 1kW of electricity, giving them a coefficient of performance (COP) of 4. In comparison, a wood-fired stove, gas boiler and electric boiler each have a COP of 1. COP measures the ratio of energy input to energy output. The higher the COP, the more efficient it is. (Note that a gas boiler may not be applicable in an off-grid house.)

A heat pump also has the most affordable running cost in comparison to wood pellets, electric boiler and gas boiler. In 2017 the annual cost to operate a heat pump at a 20kW heat load for eight hours a day, 120 days a year, in a 200-square-metre house was calculated at $1540. An electric boiler was more than three times higher than a heat pump at $4992. The comparative running cost using wood pellets was calculated at $2191, and natural gas boiler (not applicable in an off-grid house) at $1736.[9]

Heat pumps utilise electricity as their power input. They use more than 60 per cent less electricity than a traditional electric water heater,[10] however an off-grid house incorporating a photovoltaic system to generate electricity will create greater savings and environmental benefits. A 300-litre heat pump in a typical sized home requires approximately 3.5kW hours per day of electricity,[11] which a 1kW solar system can provide in most Australian locations.[12] The average rooftop solar system being installed is now more than 7kW, providing more than sufficient capacity.[13]

Combined with solar panels, a heat pump can operate like battery storage. By using built-in timers, it can be programmed to run during the warmest hours of the day to extract the maximum heat from the air. This heated water is then stored in the floor slab or a water tank to be used for hydronic heating later in the day.



CONCLUSION

Comfort Heat is a leading supplier and installer of hydronic in-floor heating systems for off-grid houses. For large or small projects, the systems are designed to create a comfortable environment and reduce operating costs. Comfort Heat's heating solutions provide architects and specifiers with the option to select renewable-energy sources, such as heat pumps and photovoltaic arrays, for designing and building off-grid houses.

Comfort Heat's hydronic systems are reliable, effective and offer energy-efficient performance. The systems utilise a multi-layered PEX pipe that includes an oxygen barrier and is designed specifically for floor heating. A range of heating controls, such as thermostats, sensors and control stations, can automate and maximise the performance and efficiency of the heating system.

Comfort Heat works closely with architects and specifiers at the design phase of a project to ensure the most efficient and effective heating solution is delivered. Specifications are properly documented and all stakeholders in the project, including structural engineers and builders, are made aware of the impact of hydronic systems, the installation process and technical requirements. Comprehensive post-sales support and service are provided to ensure success and efficiency of the solution throughout its lifecycle.

Comfort Heat's hydronic heating system is designed by highly qualified engineers, ensuring site specifications, metrics and other relevant information is factored in and the best outcome is delivered for any individual project. Committed to delivering the highest quality and best performing solution, Comfort Heat is able to design and supply a complete hydronic system and ship it to any Australian location.

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