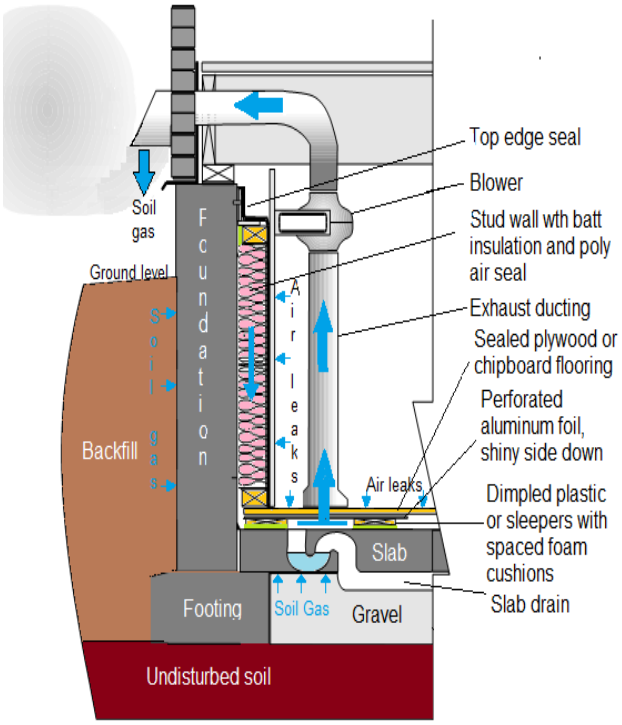
# Cold Climate Basement Living Space Protection:

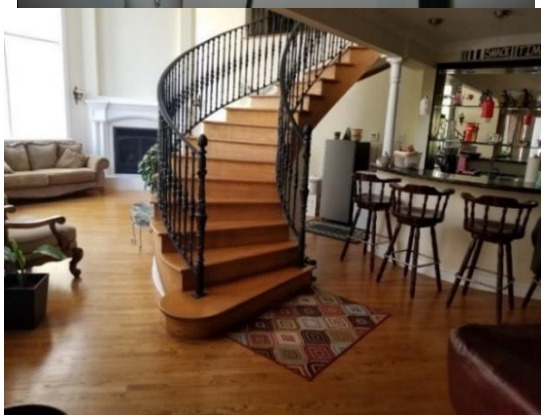
# The ECHO System - What it is, How It Works, What It Delivers, and What Can Go Wrong in Building It

## Executive Summary

This document explains what the ECHO basement depressurized and drained envelope (the ECHO System™ - Enclosure Conditioned Housing System) is, how it works, what it delivers, and the need to create an airtight envelope. Airtightness is measured during ECHO construction, and any envelope found to be inadequate is reworked until it is.





*a) Schematic of the air flow into air leaks and from a tightly sealed, drained, ventilated, and depressurized perimeter wall and subfloor ECHO envelope*

*b) The continuous duty blower exhausting the envelope and the control panel with its pressure differential meter, Blower speed control, and ECHO commissioning certificate*

*c) Example of a finished basement that has an ECHO System ventilated and drained envelope. This basement looks no different than any finished basement on the surface, except it has an ECHO blower operating with its control panel in the furnace room. As you can see the finishing is high quality, given it is protected by the ECHO envelop against foundation water leaks and its special envelope acts as a giant vacuum cleaner removing odorous, irritating and harmful soil gases and particles, and keeping material moisture content low.*

In turn, homeowners must be made aware of the system's envelope airtightness requirement so that any future contractors do not compromise it. Over thirty years of experience have demonstrated that, if undisturbed by a contractor, the system's airtightness continues indefinitely, and that even floods and sewer backups often may not compromise its continued operation.

Basements with living space are unique to Canada and the northern US and to a lesser extent Norway, Finland and central Europe. They expand above-ground living space by a third or more at a fraction of the above-ground space and property costs. However, below ground living space brings extra risks: water leakage and periodically high water table damage, hidden as well as visible mold growth, and extra soil gas exposure. The ECHO System™ established three decades ago addresses these risks and as a result has been built in hundreds of homes in Canada and the US. What is the ECHO System? It is a tightly sealed, drained, mechanically ventilated, and depressurized **envelope** within basement subfloors and perimeter insulated stud walls and **exhausted to the outdoors, drawing its intake air through envelope air leakage**.

The ECHO envelope is designed to meet three objectives: (a) provide **excellent basement air quality** as good as or better than upstairs; (b) prevent foundation **water leakage or high water table damage,** eliminating costly outside digging to seal foundation cracks and replace plugged weeping tile; and (c) **improve basement insulation performance and energy efficiently add to house ventilation.** These benefits of course depend on proper system construction and extra attention to tightly sealing of the envelope, so that it can be demonstrably depressurized throughout by 2 Pascals or more at an 80 CFM envelope exhaust rate.

Incorrect envelope construction or haphazard attention to air sealing it creates five risks: (a) **soil gas** and propagule entry into the living space; (b) basement **mold growth**; (c) **water damage** from any foundation leakage cracks; (d) inability to inexpensively recover from **floor flooding**; and (e) inadequate **house ventilation**. Any of these can compromise the system's significant health, water-management and energy benefits.

## Introduction

In cold climates such as the northern US and Canada, building codes require footings to sit below the frost line, often 4 to 6 feet (1.2 to 1.8 meters) deep, to avoid frost-heave damage. Because builders must already dig that far, excavating a little further to create a full-height basement is cost-effective: it expands above-ground living space by a third or more at a fraction of total house and property costs. North American wood-frame construction also made basements easy to insulate, drywall, and carpet. Following the post-WWII housing boom, finished basements became standard for family rooms, home theaters, and rental suites. In Canada, roughly three out of four homes have a basement.

Basements are common in several other regions, though they often are used differently than in North America. Full basements became common in Nordic single-family homes

built between the 1930s and 1980s. In Norway hilly terrain made walk-out basements practical for flattening plots and creating tax-free rental apartments, in Finland basements frequently house private saunas and utility rooms. Newer Nordic builds often favor insulated concrete slabs to cut costs and maximize energy efficiency. A full basement is very common in German-speaking Europe, traditionally divided into unheated concrete rooms for laundry, boilers, and storage, although modern German and Austrian builders routinely offer insulated, habitable basements used as guest apartments, home offices, or wellness spaces. Basements and cellars in Eastern Europe and Russia are widespread for root storage, utilities, and workshops, but finishing them as carpeted living rooms is much less common than in North America. Basements are rare where shallow frost lines let homes sit safely on inexpensive concrete slabs, as in the UK, Australia, New Zealand, and the southern US. They are also rare where water tables are high (as in Florida), there is shallow bedrock that makes deep digging prohibitively expensive, or basements are structurally risky (as in Japan and California).

Soil moisture, soil propagules and dissolved gases, can dampen and wick through naturally porous concrete foundations and enter the basement air. Gases and propagules can also enter the basement living space through concrete cracks. Most are harmless in open air, but high indoor concentrations can cause odor, health and discomfort problems. Radon gas, whose multi-year exposure at high levels can cause lung cancer, and hundreds of harmful and irritating microbial volatile organic compounds (MVOCs) and propagules, particularly after a heavy rain all can enter the living space by these two pathways. Some of these compounds have an unpleasant musty, earthy odor detected even at very low concentrations (e.g., geosmin and 2-methylisoborneol (2-MIB)). With prolonged exposure, some of these compounds can cause fatigue, headaches, eye irritation, and respiratory discomfort. Others can trigger allergies, asthma, lung inflammation, fever and flu-like symptoms (e.g., dust rich with gram-negative microbial endotoxins, and aspergillus and penicillium propagule mycotoxins).

Dehumidifiers can reduce basement dampness, but unlike the ECHO System they cannot eliminate soil gas and propagule entry, remove leakage water, or dry the underside of the subfloor and the inside of the perimeter wall construction after a flood. Such floods can originate from a laundry tub overflow or shower leakage, heavy rainfall, an area sewer backup, an indoor plumbing leak, or a leaking subsoil house water supply pipe blocked by tree roots.

The ECHO envelope was developed specifically to address basement air quality, dampness and water leakage issues. **It is a tightly sealed, connected, ventilated, and drained space within a uniquely constructed, tightly air-sealed, low-E basement subfloor and connected, tightly sealed, batt-insulated stud walls covering the below-grade portion of the foundation walls**. A **blower continuously draws house air through this** sealed subfloor and insulated stud-wall **envelope and exhausts it outdoors at rates up to 80 to 90 CFM**, keeping the envelope at negative pressure of at least 2 Pascals relative to the basement living space. This pressure difference,

continuous ventilation, and accessible drainage are central to the system's operation, and improper construction or damage can compromise them, affecting indoor air quality and the management of foundation dampness and leakage. If basement flooding or emergency flood-response measures damage the envelope seals, reconstruction is required; its extent can vary considerably.

**Terminology guide:** The **ECHO Envelope** is the complete tightly sealed, connected, ventilated, and drained space within the basement subfloor covering the basement floor slab and the stud walls covering the underground portion of the foundation walls. Its **subfloor portion** is the space within the subfloor; its **stud-wall portion** is the space within the foundation-covering stud walls. References to the floor and wall envelopes describe these connected portions, not separate systems.

The sections that follow cover four areas: (A) depressurization and air quality, (B) dampness and leakage management, (C) energy performance and floor comfort, and (D) whole-house ventilation. Each area addresses two construction-risk questions. First, what protections are lost if air leakage or flow blockage prevents an appropriately sized, continuous-duty ECHO blower from depressurizing the complete envelope? Second, what benefits are lost if key ECHO Subfloor or ECHO Wall features are missing? Such deficiencies may compromise the system's contributions to occupant health and comfort, water management, and heating-energy savings.

## A. Envelope Depressurization and Basement Air Quality

Each section below first describes how the ECHO System is intended to work and then identifies the construction or reconstruction deficiencies that would undermine that benefit.

1. **Depressurization throughout the ECHO Envelope is a primary system function.** If it is lost, odorous, carcinogenic, toxigenic, and allergenic gases and microbial propagules from the concrete and its pores, the surrounding soil, and the envelope materials themselves could enter the basement living space air. Depressurization may be lost in three ways: the envelope is inadequately sealed against air leakage; airflow is blocked at doorways or by inappropriately positioned sleepers; or airflow is blocked at the subfloor–stud-wall connection. **Drainage failure** is a related but distinct risk. For example, there may be no working slab drain; there is an improper connection between the subfloor and stud-wall portions of the ECHO Envelope can trap foundation leakage in the stud-wall portion, causing material degradation and toxigenic fungal growth; water trapped in the subfloor portion can cause similar problems.

2. When functioning properly, the ECHO System maintains a continuously depressurized envelope around the perimeter foundation walls and floor slab. **More than 30 years of experience has demonstrated that a tight seal is maintained, and depressurization is not lost over time.** This pressure barrier protects against

two kinds of contaminants. First, it prevents entry of odorous and potentially toxigenic and allergenic microbial volatile organic compounds (MVOCs) and propagules emitted by soil-related bacteria and fungi living in concrete pores and the surrounding soil. One such compound, geosmin, has an earthy odour and can often be detected in the exhaust air of an ECHO System operating at low flow rates. Second, it prevents radon emitted by the foundation and slab concrete or the surrounding soil from entering the living space. Because long-term radon exposure can cause lung cancer, limiting indoor radon to outdoor levels is an important objective, particularly in homes with children, who face longer potential lifetime exposure. For radon control, the ECHO Envelope has three advantages over sub-slab depressurization (SSD) systems. First, it does not depend on a dry, permeable gravel layer beneath the slab; high water tables, for example, can prevent SSD operation. Second, it addresses soil-gas entry through foundation wall cracks and openings, which are extensive in concrete-block and stone foundations, rather than only through the slab–foundation joint. Third, it addresses radon emitted by the concrete itself.

3. The ECHO System addresses hidden microbial growth through two mechanisms, provided envelope airflow and depressurization function properly and basement relative humidity is 55% or lower: **drying ventilation air and contaminant containment**. In homes with continuously damp soil conditions, fungal and other microbial growth is common on concealed drywall surfaces and on wood and concrete covered by batt insulation, especially in corners. This growth can release allergenic and toxigenic spores, other microbial particles, and odorous volatile organic compounds (VOCs), which wind pressure and stack pressure (from indoor–outdoor temperature differences) can draw into house air. Drying ventilation is intended to prevent fungal growth in the envelope, behind drywall, and on the underside of floor-finishing materials when house-air relative humidity is kept at 55% or less in summer and no whole-house humidification is used in winter. If growth occurs, for example from elevated house humidity or flooding, the depressurized envelope is intended to contain the gases and microbial particles released within it and prevent their entry into house air.

## B. Dampness and Leakage Management: Preventing Material Damage

4. The ECHO System's role in **preventing damage from ordinary foundation leakage** is distinct from its role in **assisting recovery after severe flooding**. In a finished basement without an ECHO System, even minor foundation water leakage may damage insulation, finishing materials and furnishings. A continuously ventilated, depressurized, and drained ECHO System is designed to prevent damage from such leakage and eliminate the need to excavate outside the foundation to seal cracks and replace clogged weeping tile. **Severe flooding presents different risks:** unusually heavy rainfall, or a sewer backup where no backflow preventer has been installed, may cause substantial water entry, basement-floor flooding, and wetting of drywall. In

these events, the ECHO system's role, if it remains functioning, is flood-recovery assistance rather than prevention of the flooding or its damage. ECHO System depressurization often continues during these events. After flooding stops, envelope ventilation helps dry the subfloor material while limiting odors in the living space. Any damage to the system caused by flooding or emergency cleanup requires repair; the extent of those repairs may vary significantly.

## C. Finished-Basement Energy Performance, and Floor Comfort

5. Envelope airflow helps preserve the foundation batt insulation's ability to limit heat loss by **keeping it dry**. Without this airflow, moisture from the soil can pass through the concrete, which readily absorbs dampness, and enter the insulation pores, reducing the insulation's effectiveness.

6. The ECHO subfloor's insulation value depends on two features working together: **low-emissivity aluminum foil with its shiny side facing down**, and **an envelope air gap equal to the combined sleeper and foam-cushion depth**. If the foil and air gap are absent, floor comfort decreases and floor heat loss increases. The foil also has a drainage requirement: it **must be punctured throughout** so that water from floor flooding can drain through it into the envelope, where it is removed by evaporation and drainage. Replacing the aluminum foil and sleepers with a dimpled plastic underlay below the envelope-sealing plywood or chipboard lowers cost, but at the price of weaker protection against water leakage and flooding and a loss of some of the energy savings and floor comfort the foil-and-sleeper design provides.

7. In an ECHO sleeper subfloor, **foam cushions separate the sleepers from the slab** and improve ventilation-air circulation within the envelope. Heat transfer through the sleepers to the slab is known as thermal bridging. By separating the sleepers from the slab, the cushions are intended to eliminate the associated energy losses and the sleepers' susceptibility to fungal degradation.

## D. Whole-House Ventilation

8. Operating the ECHO blower on high provides at least 80 CFM of house ventilation without the ground-level microbial gas and propagule intake, and the periodic filter cleaning required by heat recovery ventilators. Continuous house-air exhaust flow through the tightly sealed ECHO subfloor and perimeter stud-wall envelope provides energy-efficient whole-house ventilation. It reduces outward air-leakage heat loss by lowering wintertime house stack pressure, and it recovers heat from house radiant heat loss at above-ground air-intake leakage points and from the basement wall and floor along its envelope exhaust path to the outdoors.

## Conclusion

The priority in construction and reconstruction is to preserve a connected, tightly sealed wall–subfloor envelope that remains **depressurized by at least 2 Pascals relative to the living space**, with continuous drying airflow and effective leakage-water management. The technology once had US and Canada patent protection. But those patents expired long ago. However, it is not easy to build. Contractors require guidance and pushing to ensure that they build a very tightly sealed envelope that will depressurize by 2 Pascals or better at a bathroom fan exhaust flow rate of 80 CFM/p max. After building one, they mostly get it and enjoy the challenge to build them tighter each time. Some systems reach 30 Pascals or more at an exhaust rate of 80 CFM! It has been successfully built in many Canadian and some US homes.

Key points:

- **Air quality:** failure to depressurize the complete envelope compromises the system's primary air-quality protection.



*Artist conception of the ECHO System*

- **Water leakage and spillage management:** the system prevents damage from ordinary foundation crack leakage and a periodically high water table and can assist recovery after severe flooding or water spillage; it does not prevent the flooding or

water spilling damage. **Failure to puncture the aluminum foil** throughout blocks the drainage of floor-flooding water into the envelope and is thus problematic.

- **Energy performance:** heating-energy savings, floor comfort, and whole-house ventilation depend on the ECHO envelope construction (a tightly sealed envelope and the foil-and-sleeper subfloor with its air gap) and on continuous drying airflow through the envelope. Missing any of these reduces the intended benefits.

For further information, visit www.indoorair.ca or search online “ECHO System for basements” to obtain an AI perspective.