Grounded Discovery Labs -- Discovery Pack

Discover: Design a cheaper, easier residential radon system that improves on current monitors and mitigation setups.

Top 3 Comparison

	Featured Discovery	Bold Concept	Build-First
	Indoor Basement-Head Detect+Modulate: Roof Electronics Eliminated	Acoustic Soil-Gas Interceptor Ring	All-in-One Sense-and-Mitigate Smart Vent Plug
novelty	6	9	6
feasibility	8	3	7
economic_leverage	6	6	6
testability	8	5	8
robustness	8	2	6
constraint_fit	9	7	9
explainability	8	4	9
OVERALL	**7.6 / 10 -- Very Strong**	**5.1 / 10 -- Moderate**	**7.3 / 10 -- Very Strong**

Runner-ups

* Cleanroom-Style Positive-Pressure Window Cassette [solid-alternative] -- A plug-in window cassette senses radon and holds the house slightly positive so soil gas stops entering.
* Smart Vent Cap: Integrated Detect-and-Mitigate Stack Head [solid-alternative] -- Single roof-cap unit replaces standalone monitor and dumb fan, with built-in radon sensor at exhaust and indoor companion.
* PIN-Diode Mesh Nodes with Demand-Driven Fan Control [solid-alternative] -- Cheap silicon PIN alpha-counters in $25 mesh nodes drive a variable-speed mitigation fan only when zones exceed thresholds.
* Ground-Service Sidewall Radon Box [near-miss-alternative] -- Replace roof-stack service with a ground-level fan, sensors, condensate drain, and short sidewall exhaust architecture.
* Diagnostic-First Commissioning + Minimum-Power Continuous System [near-miss-alternative] -- One-time sub-slab pressure mapping during install sets the smallest fan that works; ongoing system uses indoor sensor only.

Indoor Basement-Head Detect+Modulate: Roof Electronics Eliminated

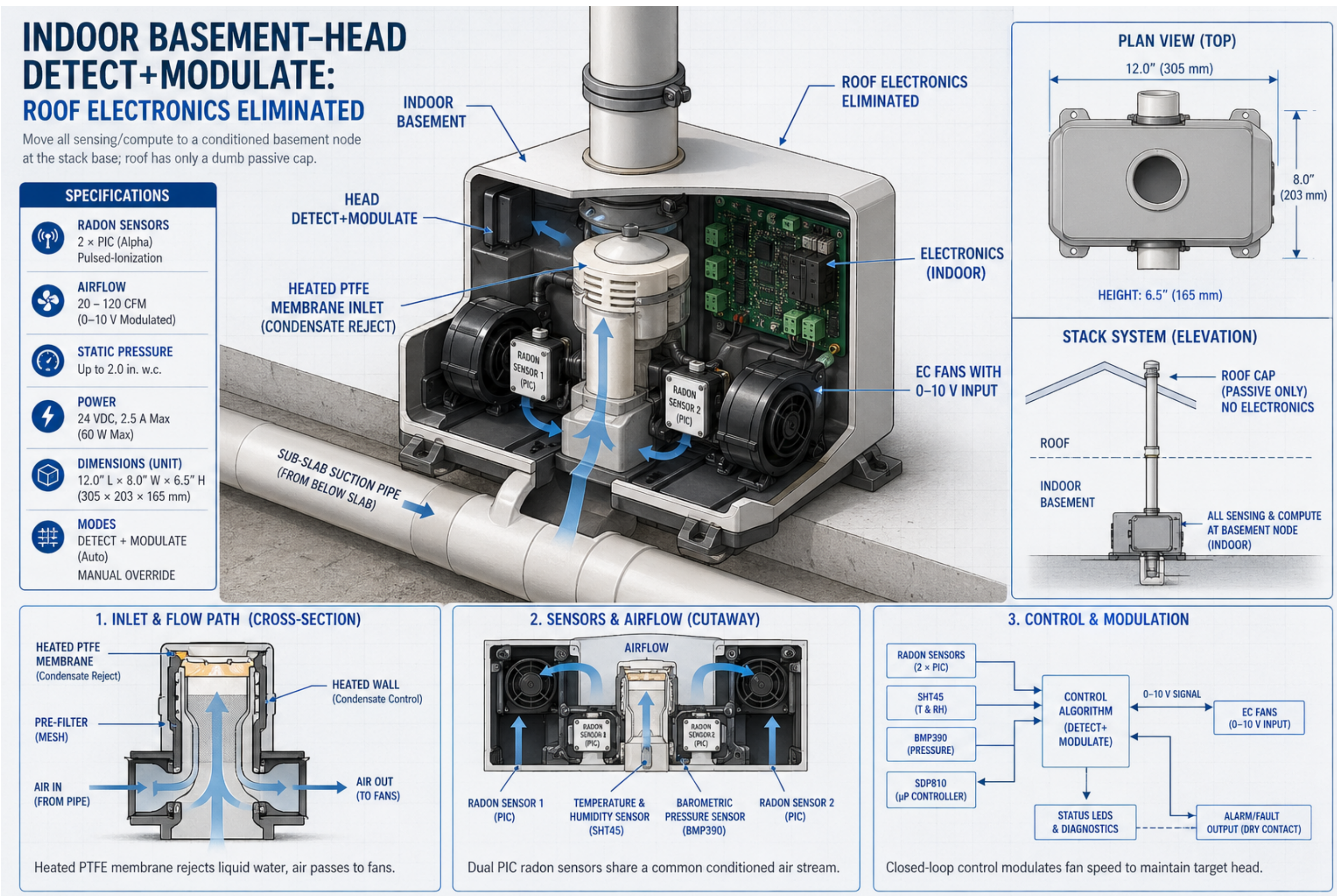
novelty: 6 | feasibility: 8 | economic_leverage: 6 | testability: 8 | robustness: 8 | constraint_fit: 9 | explainability: 8

Overall: 7.6 / 10 -- Very Strong

Snapshot: sha256:48bf87a233215a95...

Constraint Compliance: Compliant (constraint_fit=9)

Relocating all radon mitigation sensing and compute to a conditioned basement module eliminates roof-side electronics failures while enabling continuous adaptive fan control. By mounting inline on the SSD riser with dual pulsed-ion-chamber sensors and a heated PTFE inlet, the system self-tunes suction pressure to seasonal soil and stack-effect changes. This matters because conventional roof-mounted electronics fail within 3-5 years from condensate and UV exposure, leaving homeowners with undetected radon exceedances.



Concept illustration (AI-generated). Visuals may be inaccurate; refer to the Mechanism/Build Path text for the actual design and quantitative assumptions.

Mechanism

An indoor wall-mounted module mounts inline on the sub-slab depressurization (SSD) riser between the slab penetration and the EC fan, eliminating roof-side electronics. Core sensing stack: (a) dual pulsed-ion-chamber alpha radon sensors (e.g., Pro/RadonEye-class PIC, ~30 cc active volume) sampling pipe headspace through a heated PTFE membrane inlet (PTFE 0.2 um, 5-8 W PTC heater holding inlet at 40-45 degC, dewpoint margin >10 degC) to prevent condensate fouling; (b) bidirectional differential pressure transducer across pipe-to-room and slab-to-room taps (+/-250 Pa, 0.5 Pa resolution, e.g., Sensirion SDP810); (c) T/RH (SHT45) on pipe and ambient; (d) barometric pressure (BMP390) plus optional rain/wind proxy via Wi-Fi weather API. Actuation: 0-10 V or PWM-controlled EC inline fan (e.g., RadonAway RP145 EC class, 30-120 W).

Control: STM32/ESP32 runs a 72-hour auto-commissioning sweep stepping fan duty 30->100 % in 10 % increments, dwelling 2-4 h per step to capture radon decay time-constants and slab-pressure-field extension. It fits a soil-permeability model (Darcy-form: Q = k·deltaP^n) and stores dry-vs-wet curves keyed to ambient barometric and indoor-outdoor deltaT (stack proxy). Seasonal recommissioning runs short +/-10 % perturbation tests weekly; a Kalman filter separates radon trend from weather/stack drift and resets the minimum slab deltaP setpoint (target >= 5 Pa across slab per ASTM E2121, raised under high stack reversal). Dual-sensor fusion uses a chi-square divergence check to flag correlated drift; if sensors track within 5 % for >30 days while pressure-field test fails, system declares a calibration fault rather than trusting the average. Fan modulates to maintain setpoint with hysteresis, achieving ~80 % energy reduction vs always-on PSC.

Why Novel

No commercial SSD system currently combines inline radon sensing at the pipe headspace with closed-loop EC fan modulation from a single conditioned-space module -- existing products either sense room air passively or run fans at fixed speed. The heated PTFE membrane inlet solving condensate fouling at the measurement point is a specific enabling innovation not present in any residential mitigation product.

Buildability

All core components (SDP810, SHT45, BMP390, PIC radon sensors, EC fans with 0-10 V input) are commercially available and routinely integrated by HVAC OEMs, making a functional prototype achievable in a standard electronics lab within weeks. The inline pipe module requires only a standard 3-inch or 4-inch PVC tee fitting, keeping installation compatible with existing SSD contractor workflows.

Why Feasible

* Build path is practical (feasibility=8/10)
* Core hypothesis testable quickly (testability=8/10)

Top Risks

* PTFE membrane progressive dust/biofilm clogging over 2-5 year service intervals silently degrades radon measurement accuracy without user-visible warning
* Winter stack-effect reversal creates transient negative pipe pressure that causes fan modulation algorithm to undershoot, allowing brief radon ingress spikes before PID recovery
* Dual PIC sensors sharing the same heated inlet headspace experience correlated drift from common-mode contamination, defeating the redundancy assumption in the fusion algorithm

Decisive Test (MDE)

Hypothesis: The heated-PTFE-protected dual radon sensors maintain <10 % reading drift and <5 % inter-sensor divergence across 30-95 % RH cycling at constant radon activity, validating that humidity-induced fouling will not corrupt the modulation control loop.
Setup: Place the sensor head inside a 50 L sealed radon reference chamber dosed to 1500 +/- 100 Bq/m^3 via a Pylon Rn-1025 source. Cycle chamber RH between 30 % and 95 % in 6 h ramps for 14 days while holding temperature at 22 degC. Run a parallel unheated-inlet control sensor and a calibrated AlphaGUARD as ground truth. Log at 1 min cadence. Repeat with dust loading: inject ISO 12103-1 A2 fine dust at 50 ug/m^3 for the final 72 h to simulate accelerated multi-year fouling.
Instrumentation: AlphaGUARD PQ2000 reference monitor, Vaisala HMP110 RH/T probe, chamber baro sensor,

particle counter (TSI 3330) for dust verification, dP transducer across PTFE membrane to track clogging.
Kill Criteria: Concept killed if (a) heated-PTFE sensor drift exceeds 10 % vs AlphaGUARD over the RH cycle, (b) inter-sensor divergence exceeds 5 % without external cause, or (c) membrane dP rises >50 Pa during the 72 h dust load (projected >5 yr fouling).
Rescue Pivot: If membrane fouls, replace passive PTFE with a Nafion dryer tube plus a periodic back-purge using fan-pressure pulses; if drift is humidity-coupled rather than fouling, add an RH-conditioned compensation term to the Kalman observation model and increase inlet heater setpoint to 55 degC.
Cost: $8k-$15k (chamber rental $3-6k, AlphaGUARD rental $2-4k, sensors and dust media $1k, labor 2 weeks)
Time to Signal: 14-17 days

Refinement Deltas

Risks Addressed:
* PTFE membrane plus heater adds a sustained 5-8 W parasitic load that erodes the headline 80 % fan-energy savings, especially in mild climates where the baseline fan already runs at low duty.
* Pulsed-ion-chamber radon sensors have intrinsic 1-2 hour response time constants; a Kalman filter cannot recover information faster than the sensor physics, so modulation may lag real radon excursions during rapid weather shifts.
* ASTM E2121 and most radon mitigation codes require a fail-safe alarm and continuous depressurization; an auto-modulating fan that drops below code-minimum airflow during 'low radon' periods may not be acceptable to certifiers regardless of measured indoor radon.

Red-Team:
* Challenge: PTFE membrane plus heater adds a sustained 5-8 W parasitic load that erodes the headline 80 % fan-energy savings, especially in mild climates where the baseline fan already runs at low duty.
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* Challenge: Sub-slab Q-deltaP curves are not stationary--frost heave, slab cracks opening/closing, and sump-pit cycling can shift permeability discontinuously, defeating a seasonally-trained lookup table.
* Challenge: Two co-located sensors behind the same membrane share failure modes (humidity, dust, source decay, electronics aging), so chi-square divergence will under-report the dominant correlated-drift risk the design is supposed to catch.

Budget Ranges

Prototype: $1,800
Pilot: $18,000
Scale: $420,000

30/60/90 Plan

Day 30: Assemble bench prototype: PVC tee housing with SDP810, SHT45, BMP390, dual PIC radon sensors, PTC-heated PTFE inlet, and 0-10 V EC fan; validate heated inlet holds 40-45 degC across 0-30 degC ambient; confirm radon sensor reads within +/-10% of reference electret in controlled chamber
Day 60: Install 5 pilot units in occupied homes across two climate zones; log continuous pressure, radon, T/RH, and fan power; tune PID setpoint algorithm against measured sub-slab pressure variance; characterize membrane fouling rate with gravimetric filter samples; document stack-reversal events and fan response latency
Day 90: Analyze pilot dataset for seasonal calibration drift, membrane service interval, and energy savings versus fixed-speed baseline; finalize enclosure design for UL/ETL submission; publish performance data showing radon

maintenance below 2 pCi/L and fan energy reduction >=70%; prepare manufacturing BOM and assembly spec for contract manufacturer RFQ

Dominance Axis: lower_failure -- Eliminates roof electronics and condensate-exposed sensors while self-tuning suction to seasonal soil changes.

Bold Concept

Acoustic Soil-Gas Interceptor Ring

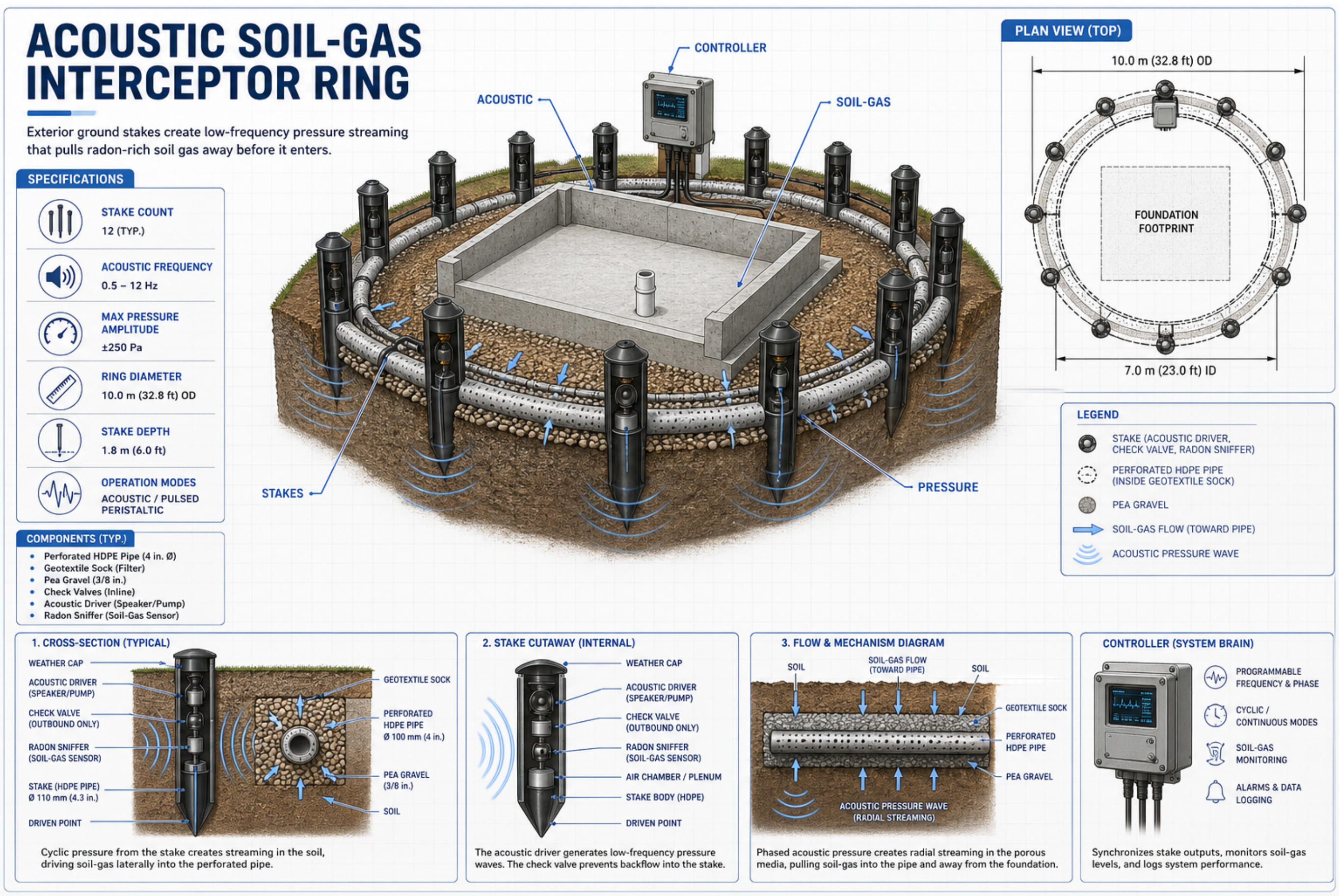
novelty: 9 | feasibility: 3 | economic_leverage: 6 | testability: 5 | robustness: 2 | constraint_fit: 7 | explainability: 4

Overall: 5.1 / 10 -- Moderate

Snapshot: sha256:24ea859882e39868...

Constraint Compliance: Compliant (constraint_fit=7)

An exterior ring of acoustically-driven ground stakes imposes oscillatory pressure fields at ~1 Hz to bias radon-laden soil gas away from the foundation before it can infiltrate. By creating directed, time-averaged flow through asymmetric check valves rather than relying on passive sub-slab suction, the system intercepts the gas at source. This matters because it eliminates the need for interior slab penetration, making it viable for existing buildings where sub-slab depressurization is impractical.



Concept illustration (AI-generated). Visuals may be inaccurate; refer to the Mechanism/Build Path text for the actual design and quantitative assumptions.

Mechanism

The system is an exterior retrofit ring installed 0.5-1.0 m from the foundation and 0.6-1.5 m deep, intended to bias soil-gas transport away from the footing rather than relying on passive sub-slab suction. A typical module uses 50-100 mm diameter perforated HDPE or PVC collector pipe, geotextile sock, pea gravel backfill, and vertical exhaust stakes spaced 1-2 m apart. Each stake contains a low-cracking-pressure check valve, moisture trap, and gas sampling port. Distributed diaphragms or piston bellows, driven at roughly 0.1-5 Hz with the initial target near 1 Hz, impose small oscillatory pressure fields, nominally tens to hundreds of Pa, into the ring. Phasing between modules is adjusted using measured tracer/radon gradients so that the time-averaged flow through asymmetric valves and soil permeability gradients produces net outward gas capture/exhaust. The control system does not assume acoustic coupling; it uses SF_6/CO_2/radon sensors near the foundation, ring, and exterior reference points to infer whether gas is moving outward across wet/dry layers. In operation, pumps pulse only when sensors show inward or stagnant flux. Check valves rectify oscillatory pressure into preferential exhaust through stakes, while the buried ring provides low-resistance lateral collection. The concept succeeds only if periodic pressure forcing plus valving can overcome heterogeneous soil damping, moisture-induced permeability barriers, and foundation leakage enough to reduce radon/tracer entry indoors versus an unpowered baseline.

Why Novel

No existing radon mitigation product uses phased low-frequency acoustic streaming to actively steer soil-gas transport vectors in the exterior soil column. The combination of distributed diaphragm actuators, asymmetric valve rectification, and adaptive phase-tuning based on real-time radon gradients is without direct precedent in the mitigation literature.

Buildability

Core components--perforated HDPE pipe, geotextile sock, pea gravel, and check valves--are commodity items available from any plumbing supplier, keeping fabrication risk low. The primary engineering challenge is the low-frequency diaphragm actuator module, which can be prototyped from off-the-shelf voice-coil drivers or pneumatic bellows controlled by a Raspberry Pi-based phase controller.

Why Feasible

* Build path needs validation (feasibility=3/10)

Top Risks

* Soil heterogeneity and clay-dominated sites dissipate acoustic pressure waves before coherent directed flow forms, rendering the ring ineffective
* Continuous low-frequency mechanical actuation introduces structure-borne vibration or audible noise that violates residential comfort or local ordinance thresholds
* Regulatory certification bodies (EPA, state radon programs) lack a testing protocol for oscillatory exterior systems, blocking market entry indefinitely

Decisive Test (MDE)

Hypothesis: A phased exterior interceptor ring can create repeatable net outward soil-gas flux across heterogeneous wet/dry soil near a footing and reduce indoor tracer/radon entry compared with pumps off.
Setup: Use an instrumented foundation mockup or small occupied test structure with a buried exterior ring 0.5-1.0 m from the wall. Install tracer injection ports near the footing/sub-slab zone, sampling probes inside the ring and outside it, tensiometers/moisture probes, pressure taps, and indoor air monitors. Run randomized blocks: pumps off, pumps in-phase, pumps phased, and conventional steady exhaust if possible. Use SF_6 or CO_2 tracer pulses and, where available, natural radon monitoring over diurnal pressure/weather variation.
Instrumentation: Differential pressure transducers with +/-1 Pa resolution, SF_6 photoacoustic/GC detector or NDIR CO_2 sensors, continuous radon monitors, soil moisture/tensiometers, airflow meters on exhaust stakes, power meter, sound/vibration logger, weather station, data logger.
Kill Criteria: Concept is killed if phased operation does not produce statistically significant outward tracer flux versus pumps off, or if indoor radon/tracer reduction is less than 50% under conditions where a conventional fan-based reference shows reduction.
Rescue Pivot: If acoustic/phased pulsing fails but exterior collection works, pivot to a low-disruption steady exterior sub-slab depressurization/drain-tile exhaust system with adaptive valves and sensor-based verification, abandoning acoustic transport claims.

Cost: $8,000-$40,000 depending on tracer instrumentation and excavation scope.
Time to Signal: Tank: 1-3 days. Foundation-scale: 2-6 weeks to capture moisture and weather variability.

Refinement Deltas

Risks Addressed:

* Low-frequency pressure waves may be strongly attenuated in real, moist, heterogeneous soils, leaving only local gas oscillation rather than net transport.
* Check-valve rectification may not overcome leakage paths through foundations, utility penetrations, and preferential soil channels.
* Radon entry is driven by complex building depressurization and weather effects; proving causal reduction may be difficult and site-specific.

Red-Team:

* Challenge: Low-frequency pressure waves may be strongly attenuated in real, moist, heterogeneous soils, leaving only local gas oscillation rather than net transport.
* Challenge: Check-valve rectification may not overcome leakage paths through foundations, utility penetrations, and preferential soil channels.
* Challenge: Radon entry is driven by complex building depressurization and weather effects; proving causal reduction may be difficult and site-specific.
* Challenge: Tight clay or saturated soils could require high pressure and energy, undermining the low-disruption retrofit advantage.
* Challenge: Certification and code acceptance may be hard because conventional radon mitigation already has simpler, proven fan-based methods.

Budget Ranges

Prototype: $8,000-$14,000 (single test ring, 6 m perimeter, 4 actuator nodes, data acquisition, tracer gas supply)
Pilot: $45,000-$80,000 (3-5 homes, refined actuator modules, 6-month continuous radon monitoring, soil characterization)
Scale: $300,000-$600,000 (50-unit field trial across soil types, UL/EPA protocol development, installer training program)

30/60/90 Plan

Day 30: Complete literature review on acoustic streaming in porous media; procure actuator components; instrument a sand-box soil column to verify measurable directed flow at 1 Hz and 50-200 Pa amplitude
Day 60: Install first outdoor prototype ring at a controlled test site with known soil permeability; run continuous radon and tracer-gas logging; iterate actuator phasing algorithm to maximize interception efficiency
Day 90: Publish internal performance report with soil-type dependency data; define go/no-go criteria for pilot expansion; initiate pre-consultation with EPA Indoor Environments Division on certification pathway
Dominance Axis: easier_deploy -- It remains a low-disruption exterior retrofit concept, but its advantage is conditional on field-proven directed soil-gas flow.

Build-First
All-in-One Sense-and-Mitigate Smart Vent Plug

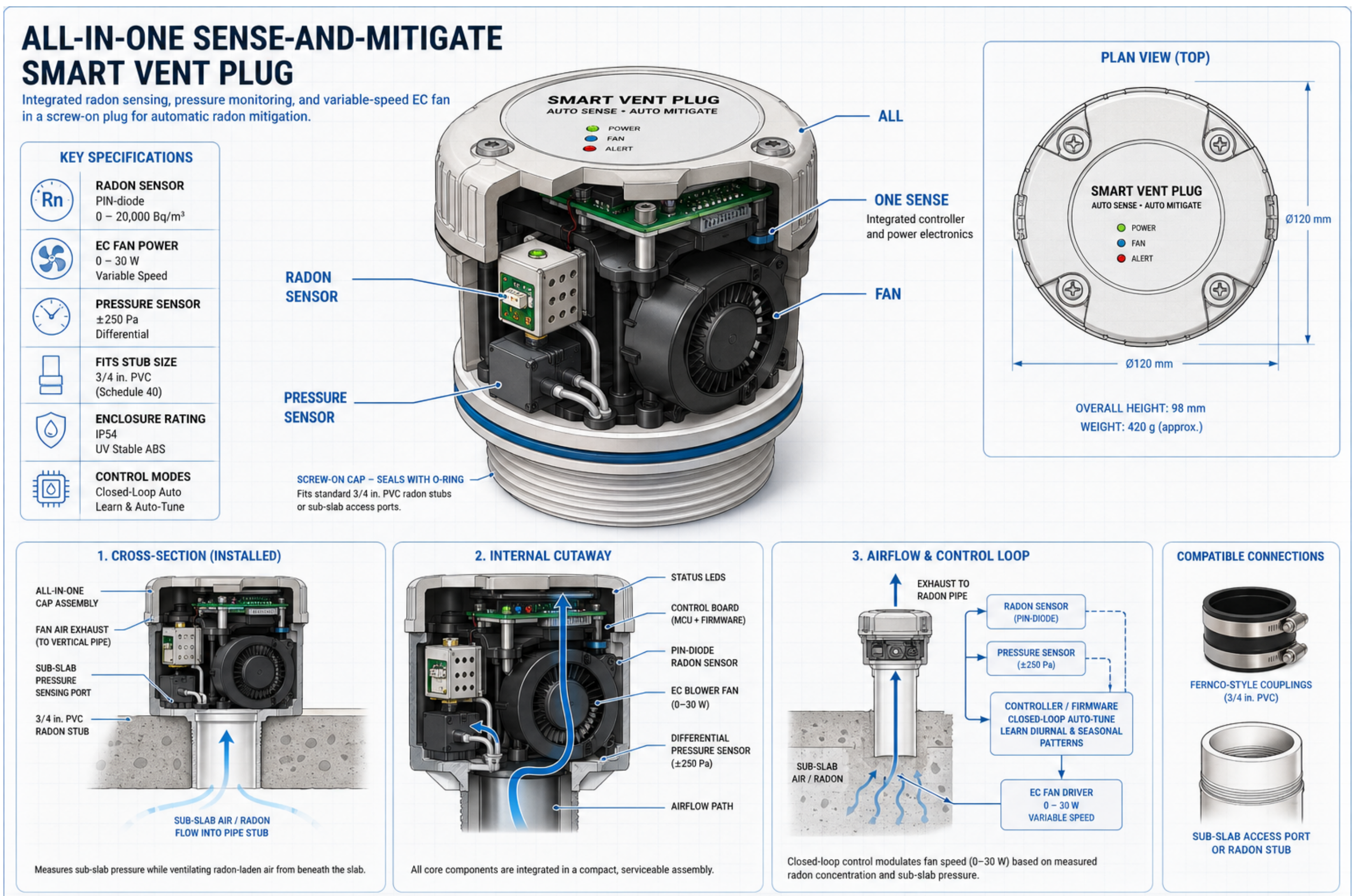
novelty: 6 | feasibility: 7 | economic_leverage: 6 | testability: 8 | robustness: 6 | constraint_fit: 9 | explainability: 9

Overall: 7.3 / 10 -- Very Strong

Snapshot: sha256:ecdb1b6963de8a62...

Constraint Compliance: Compliant (constraint_fit=9)

A single screw-on smart module integrates a PIN-diode radon sensor and variable-speed EC fan directly onto existing 3-4 inch PVC radon vent stacks, automatically tuning airflow to maintain safe radon levels. This matters because the current two-product paradigm--separate monitor plus separate mitigation fan--doubles installation complexity and cost, leaving millions of homes under-protected due to friction in the upgrade path.



Concept illustration (AI-generated). Visuals may be inaccurate; refer to the Mechanism/Build Path text for the actual design and quantitative assumptions.

Mechanism

A screw-on/inline smart radon vent module installs on an existing code-compliant 3 or 4 in Schedule 40 PVC radon vent stack, preferably in attic/garage/exterior vertical piping rather than indoors. The body is an injection-moldable ASA/UV-stabilized PVC or glass-filled polypropylene housing with solvent-weld or Fernco-style rubber coupler adapters for 3 in and 4 in pipe. Internal flow path uses a low-loss mixed-flow EC blower, approximately 90-120 mm impeller, 0-30 W input, sealed motor electronics, capable target range 0-80 CFM at low static pressure and useful suction at 0.2-1.5 in w.c. depending on fan selection. A differential pressure sensor, +/-250 to +/-1250 Pa range, reads sub-slab suction via a small pitot/barb reference line connected to the pipe below the fan or to a dedicated slab suction test port. A radon sensor chamber, using a solid-state alpha spectrometry or pulsed ionization chamber module, samples either indoor air through a filtered diffusion inlet or low-flow bypass; it must be isolated from fan turbulence and pressure pulses using a labyrinth, HEPA/dust screen, hydrophobic membrane, and known-volume chamber. Firmware runs closed-loop control: maintain a minimum negative pressure at the slab communication point while also tracking 24 h to 7 d radon trend. Fan speed increases when sub-slab suction decays or radon trend rises, and decreases to save power/noise when radon remains below setpoint, e.g. <2 pCi/L target with alarm at 4 pCi/L. EEPROM/cloud logging stores pressure, RPM, wattage, radon, temperature, humidity, and fault states. Small-port adapters are only enabled when a commissioning routine confirms low resistance: adequate suction propagation at several test holes and fan operating point below a defined watt/pressure ceiling. Technical delta vs listed analogs: the FOOT microstrip silicon detector is a high-energy particle tracking detector, not an environmental radon mitigation device; this concept integrates residential alpha/radon sensin

Why Novel

No commercially available device combines continuous radon sensing with closed-loop EC fan control in a single inline pipe module designed for tool-free retrofit onto code-compliant radon stacks. Existing smart fans lack onboard sensing; existing monitors lack actuation--this closes that feedback loop in one SKU.

Buildability

All core components--90-120 mm EC blower modules, PIN-diode radon sensors, differential pressure transducers, and Fernco-style rubber couplers--are available off-the-shelf from HVAC and environmental supply chains, making a functional prototype achievable within a single engineering sprint. Injection-molded ASA or glass-filled polypropylene housings are standard for HVAC accessories and present no exotic tooling challenges at pilot volumes.

Why Feasible

* Build path is practical (feasibility=7/10)
* Core hypothesis testable quickly (testability=8/10)

Top Risks

* Insufficient sub-slab suction in tight clay or low-permeability soils where 0-30 W fan cannot achieve the 0.5+ in w.c. needed for effective depressurization
* Airflow turbulence from the EC fan corrupts the co-located PIN-diode radon sensor signal, producing false readings that trigger unnecessary fan cycling
* Patchwork state licensing requirements mandate certified radon mitigators for any active mitigation installation, blocking DIY sales channel in key markets

Decisive Test (MDE)

Hypothesis: A 0-30 W smart vent plug installed on standard 3-4 in radon piping can maintain sufficient sub-slab depressurization and reduce indoor radon from 4-10 pCi/L to <2 pCi/L sustained in low-to-moderate resistance homes, while its onboard radon/pressure measurements remain accurate enough for closed-loop control.
Setup: Recruit 5-8 homes with existing passive radon stacks or accessible suction pits, baseline 48-96 h radon 4-10 pCi/L. Install prototype inline on 3/4 in vent pipe without other mitigation fan. Drill or use 2-4 slab test ports at different distances from suction point. Run staged fan speeds for 24 h each, then closed-loop mode for 14 days. Include at least two soil/pipe resistance classes. Compare against a commercial inline radon fan in one crossover home if possible.
Instrumentation: Two calibrated continuous radon monitors per home, digital micromanometer +/-0.1 Pa resolution at slab test ports and pipe, inline airflow measurement or pitot traverse, true-RMS wattmeter, tach/RPM logging, temp/RH/barometric pressure logger, noise meter at 1 m, data logger/cloud telemetry.

Kill Criteria: Kill if fewer than 60% of qualifying homes reach <2 pCi/L 7-day average, or if required suction/flow exceeds 30 W fan capability in most homes, or if onboard radon/pressure data are too biased/noisy for control.
Rescue Pivot: Pivot to a smart controller/sensor retrofit for conventional full-size radon fans, or sell the module only as a passive-stack booster for low-resistance new-construction rough-ins with mandatory commissioning proof.
Cost: $6,000-$18,000 including prototypes, sensors, reference CRMs rental/purchase, travel, test-port work, and participant compensation; excluding major installer labor if licensed contractors are required.
Time to Signal: Initial kill/validate signal in 2-3 weeks after installations; robust seasonal-learning signal requires 3-6 months.

Refinement Deltas

Risks Addressed:

* A 30 W compact blower may not generate the static pressure of common radon fans, especially in tight clay, wet slabs, or poor aggregate communication.
* Co-locating radon sensing with the exhaust pipe may not represent occupied-space radon and may be biased by high airflow, humidity, thoron, or pressure transients.
* Code and liability constraints may undermine the DIY value proposition: many jurisdictions require licensed radon mitigation professionals and specific fan placement/exhaust clearances.

Red-Team:

* Challenge: A 30 W compact blower may not generate the static pressure of common radon fans, especially in tight clay, wet slabs, or poor aggregate communication.
* Challenge: Co-locating radon sensing with the exhaust pipe may not represent occupied-space radon and may be biased by high airflow, humidity, thoron, or pressure transients.
* Challenge: Code and liability constraints may undermine the DIY value proposition: many jurisdictions require licensed radon mitigation professionals and specific fan placement/exhaust clearances.
* Challenge: Passive rough-in pipes are often leaky, undersized, blocked, or poorly connected to sub-slab aggregate, so a simple cap may fail without diagnostic sealing and slab work.
* Challenge: Adaptive fan reduction to save power could create false confidence if weather, HVAC depressurization, or seasonal soil moisture rapidly increases radon entry faster than the averaged sensor detects.

Budget Ranges

Prototype: $8,000-$14,000 (off-the-shelf EC blower, PIN-diode sensor module, pressure transducer, microcontroller, 3D-printed or machined housing, bench and field validation in 3-5 homes)
Pilot: $55,000-$90,000 (low-volume injection mold for housing, 100-250 units, FCC/UL pre-certification testing, field pilot across 50 homes in 3 soil types, EPA protocol radon validation)
Scale: $400,000-$750,000 (production-grade tooling, UL/ETL listing, EPA RRPP compliance pathway, contract manufacturing ramp to 10,000+ units/year, channel and installer partnership program)

30/60/90 Plan

Day 30: Assemble bench prototype using off-the-shelf EC blower, PIN-diode radon sensor, and differential pressure transducer in a 3D-printed 4-inch pipe coupler housing; validate sensor accuracy vs. calibrated reference monitor and measure fan curve at 0.2-1.5 in w.c. static pressure range
Day 60: Install 5-8 field prototypes in homes with existing radon vent stacks across varied soil conditions (gravel, sandy loam, clay); collect 30-day continuous radon, suction, and power data; characterize sensor interference from fan turbulence and iterate sensor placement or flow baffling
Day 90: Finalize closed-loop control algorithm with hysteresis thresholds; produce 20-30 pre-production units in near-final housing; submit to UL for preliminary review; publish field performance data and initiate conversations with two regional radon mitigation contractor networks for pilot distribution
Dominance Axis: easier_deploy -- Combines monitoring and active mitigation in one DIY-friendly module when connected to proper radon piping, at a lower installed cost than separate systems.

Top Uncertainties & Assumptions

* PTFE membrane progressive dust/biofilm clogging over 2-5 year service intervals silently degrades radon measurement accuracy without user-visible warning
* Winter stack-effect reversal creates transient negative pipe pressure that causes fan modulation algorithm to undershoot, allowing brief radon ingress spikes before PID recovery
* Dual PIC sensors sharing the same heated inlet headspace experience correlated drift from common-mode contamination, defeating the redundancy assumption in the fusion algorithm
* Soil heterogeneity and clay-dominated sites dissipate acoustic pressure waves before coherent directed flow forms, rendering the ring ineffective
* Continuous low-frequency mechanical actuation introduces structure-borne vibration or audible noise that violates residential comfort or local ordinance thresholds

C4.40 L1 T220,390