

Electrostatic fog visibility bench protocol

WX-FOG-001 | Version 0.2 | Prepared for weatherhill | 11 October 2026

Purpose: determine whether a specified powered electrostatic apparatus produces a repeatable, useful reduction in fog optical extinction, and identify how much of the result depends on a dedicated collector.

Team decision: retain randomized powered-versus-passive collection as the primary experiment. Add a qualified fog population, an explicit flow-speed discovery matrix, and energy per processed air volume. Assess open-boundary performance and commercial readiness separately. Prior electrostatic fog-clearing experiments exist; this project must establish reproducibility and a useful operating envelope. [S21, S22]

Status: draft for technical review and later preregistration. No experimental data have been collected or analyzed for weatherhill under this protocol. The apparatus, operating envelope, sample size and safety settings must be entered in the closure register before a version 1.0 is sealed. This document does not establish permission to operate at any site.

Decision item	Proposed specification
Primary outcome	Reduction in downstream optical extinction, normalized to transit-aligned upstream extinction, relative to the passive collector.
Initial usefulness threshold	20% reduction. This is a proposed engineering threshold, not a published standard or a validated customer requirement.
Evidence standard	New randomized confirmation data, analyzed across independent test days, with a statistical interval and a bounded measurement-bias allowance.
Decision	Report the optical result, measurement validity, delivery/mechanism status, reliability and product advancement separately. Invalid measurements do not establish a null physical effect.
First scope	Contained apparatus with one frozen fog state and flow. Any natural-fog or site-scale claim requires evidence in the claimed regime.

Revision basis: independent review of Claude’s October 2026 amendments and the full version 0.1 protocol. Appendix D records decisions R1 to R8; Appendix E supplies the facility inquiry. This remains a design document, not a preregistered or executed study.

The protocol adopts the measurement-first discipline of MaxwellX MX-FG-001: qualify instruments, freeze analysis, preserve raw records, challenge artifacts, and retain explicit failure outcomes. Its magnetic-field model, frequencies, geometry and numerical acceptance threshold do not transfer to fog.

1 Scientific question and claim boundary

The test asks whether powering one specified assembly changes extinction under one measured fog state at a specified air throughput. A successful result supports that apparatus and those conditions. Rainfall enhancement, an open cleared zone, other fog populations and profitable operation are separate claims.

Direct optical measurements during electrostatic clearing were published in 2021, and a 2025 paper describes laboratory and historical field experiments. These studies include a collector occupying only part of a large chamber and outdoor fog; absence of prior visibility or open-boundary data is therefore not a defensible novelty claim. Their controls and operating conditions do not substitute for the present randomized comparison. [S21, S22]

H1: the energized collection assembly reduces optical extinction relative to the identical passive assembly. H2: treatment without a dedicated collector changes extinction relative to its own unpowered baseline; improvement, no change and worsening are all possible. H3: after a valid H1 result, a separately specified partial-span or open-boundary apparatus can improve visibility over a useful spatial region despite bypass and lateral replenishment.

Reading observed changes in small-droplet populations after charging, including a 95.3% mass-concentration increase in one 1 micrometre bin. Its aircraft experiment found responses to unipolar emission and a smaller bipolar response. These results do not directly establish restored or worsened visibility. MIT demonstrated electrically assisted droplet collection. Measure optical outcome and water destination instead of inferring one from the other. [S1, S2, S26]

Power-on versus power-off estimates the complete intervention, including electrical forces, ionic wind, heating, chemistry and deposition. A mechanism-specific claim needs additional evidence. A short-path optical-range calculation does not establish a cleared corridor of that length. H3 must map optical benefit, bypass fraction, entrainment and time dependence in its own protocol.

2 Apparatus and experimental arms

Use a contained, preferably once-through test section with defined inlet, outlet, optical paths, charge sampling plane, collector, drainage and treated exhaust. The downstream air must pass through a facility-approved containment system. Recirculation is acceptable only after repeat exposure and carryover have been characterized and a revised exposure definition is frozen.

Choose one primary fog regime before discovery. Ultrasonic water fog is suitable for instrument qualification and explicitly apparatus-bound optical claims. Natural-fog relevance requires a characterized population of hydrated aerosol and activated droplets appropriate to the intended site. A generic salt recipe alone does not establish representativeness. Record dry-seed chemistry and distribution, water quality, wet size spectrum, liquid water, temperature, humidity history, activation state, conductivity, background charge and airflow. [S23, S24]

If water-only fog is used initially, any later target-fog confirmation is a separate experiment with its own uncertainty and claim boundary. It cannot inherit the first experiment’s confidence interval. Prefer a representative seeded regime for the primary confirmation if a facility can qualify it.

Arm	Emitter treatment	Collector configuration	Comparison
A	Off	No dedicated collector; empty support frame	Baseline for B
B	On	Same empty frame as A	B against A
C	Off	Installed collector assembly	Baseline for D
D	On	Identical collector assembly as C	D against C; primary

Keep the relevant actuator and support hardware, external electronics and ordinary flow control physically present in each matched on/off comparison. Use an installed full-span collector for C/D. Match prescribed throughput, qualify spatial velocity profiles and measure the residual flow difference. Equal bulk flow alone does not establish equal profiles. Inserting a collector changes airflow and electrical boundaries, so D against B does not isolate collection cleanly.

Arm B is described as treatment without a dedicated collector. Chamber walls can still collect charged droplets. An installed grounded mesh is also not electrically inert merely because a separate collector supply is off. Record the grounded and floating surfaces in every configuration.

3 Measurements and what they establish

Quantity	Measurement	Required qualification
Primary extinction	In situ upstream and downstream transmission over measured paths; fixed optical alignment and wavelength	Known attenuation, clean-air references, wet-window detection, electrical interference and usable dynamic range.
Wet particle population	Wet aerosol/droplet spectrum spanning the extinction-relevant range; dry-seed measurement reported separately	Size response, coincidence, upper and lower tails, humidity preservation and charge-dependent inlet losses.
Liquid water	Independent reference where available; separately identify spectrum-derived estimates	A calculation from the same droplet instrument is not independent corroboration.
Captured water	Timed gravimetry of drain output and retained water; separate wall and outlet-trap accounting	Drain lag, evaporation, retained films, re-entrainment and blank mass changes.
Electrical exposure	Corona: target-plane droplet charge plus field and ion diagnostics. Non-corona: mechanism-appropriate field and trajectory diagnostics	Separate ions from droplets; resolve or bound bipolar cancellation. Qualify any alternative architecture separately.
Environment and flow	Air throughput and profile, temperature, dew point, pressure drop	Stability, upstream influence and differences caused by powering the assembly.
Energy and by-products	Integrated wall-plug energy and actual processed air volume for each arm; ozone and other required monitoring	State the product and test-infrastructure boundaries. Validate meters and reviewer-set stop limits.

An ion counter measures small ions and a field mill measures electric field; neither substitutes for droplet charge. A Faraday collector and electrometer can receive both ion and droplet current. Net charge-to-mass can also conceal a bipolar population. If the instrument resolves only net charge, report exactly that limitation and do not claim a complete charge distribution.

Fog sampling is particularly vulnerable to size-dependent losses and optical assumptions. Charged droplets may deposit in a sampling tube and create an apparent reduction at a counter. Keep the primary endpoint in situ and qualify sampled measurements against it. The FM-100 instrument study documents substantial fog-sampling and sizing uncertainties. [S3]

Select the optical path from a sensitivity calculation and freeze the qualified extinction range, path length, wavelength and spatial coverage. Light fog over a short path may produce a signal below drift or wet-window error. Synchronize upstream and downstream records using the measured transit lag; qualify that treatment does not alter the upstream reference.

Report net depletion or enrichment by wet size, alongside number-, liquid-mass- and modeled-extinction-weighted responses. A changing size bin does not by itself measure collection: evaporation, growth and coalescence move particles between bins. Aim to resolve about 1 micrometre and below where needed; bound the missing submicron and large-droplet contributions rather than assuming a cutoff is sufficient. [S3, S23, S24]

Compare spectrum-predicted extinction with direct extinction using a stated optical model, wavelength, refractive index and uncertainty budget. Predeclare an optical-closure tolerance. Failed spectral closure limits mechanism and transfer claims; it need not invalidate sound direct optics. Conversely, a plausible spectrum cannot rescue a biased primary optical channel. A dried aerosol size distribution is not the ambient wet distribution.

4 Qualification before efficacy testing

Qualification establishes whether the apparatus can answer the question. Its results are engineering observations and are excluded from confirmatory effect estimates. The following are proposed acceptance requirements; any revision must be documented before confirmation begins.

Challenge	Acceptance or required action
Optical calibration	Recover known attenuations across the planned fog range. Build an uncertainty budget for the final treatment contrast, including reference drift and alignment.
Powered clear-air challenge	Operate the complete electronics with no fog, using appropriate references. Bound false optical and acquisition signals at both measurement planes.
Fog dilution control	An independently prescribed dilution must change extinction in the expected direction and magnitude within the combined uncertainty budget.
Spatial challenge	Map at least three predeclared positions, expanding the grid as needed to establish spatial representativeness. Freeze area weighting or restrict the claim to the observed paths.
Sampling challenge	Test charged versus uncharged inlet losses and distinguish ions from droplet charge. Mark unqualified electrical measurements as diagnostics only.
Flow and thermal challenge	Map powered/unpowered profiles, thermal and humidity gradients, and transit lag at every admitted speed. Maintain bulk flow within 3% of target and qualify the paired optical sampling volumes.
Recovery challenge	Determine reset times for extinction, electrical background, fog population, flow, wet films and drainage; check inlet-to-outlet evaporation and recirculation carryover.
Bias budget	Require a bounded residual systematic error no greater than 0.05 in the log treatment ratio. This proposed bound is approximately a 5% ratio error; it is not five percentage points of clearing.

The bias budget must be supported by the challenge data and instrument calibration, not declared from sensor brochures. Avoid counting the same random noise in both the statistical interval and the systematic bound. If the residual bound cannot be established, the efficacy decision is HOLD.

Proposed starting-state rule: during the final 120 seconds before treatment, inlet extinction has a coefficient of variation no greater than 5%, bulk throughput remains within 3% of target, and all other registered fog-state bounds hold. Qualification must show that these tolerances are achievable. Temperature, dew-point and size-spectrum bounds are apparatus-specific entries in the closure register.

Before a subsequent run, require at least five measured residence times and at least 120 seconds of stable baseline after all reset criteria are satisfied. Use the longer empirically qualified recovery interval if charge, wall films or drainage recover more slowly. If a repeatable starting state cannot be recovered, use fresh independent fog batches and revise the design before confirmation.

5 Discovery of an operating envelope

The default matrix compares two geometries within the same qualified corona architecture, positive and negative polarity, two measurable nonzero exposure bands, and three qualified face velocities. Proposed velocities are 1, 2 and 4 m/s; these are requirements to qualify, not assumed facility capabilities. Hold one primary fog state fixed. Each matched contrast consists of two runs with randomized order.

Stage	Registered allocation	Purpose
Screen	24 C/D contrasts: 2 geometries × 2 polarities × 2 bands × 3 speeds, one pair per cell	Locate candidate operating conditions; no confirmatory claims.
Refine	12 C/D contrasts: the top two eligible cells, six new pairs each, spread across at least three days	Select the final setting using independent refinement results.
No collector	12 A/B contrasts: positive, negative and bipolar modes × 2 prespecified speeds × 2 pairs	Bounded exploratory assessment at one locally qualified exposure setting per mode.
Variance pilot	12 fresh C/D contrasts at the final setting: two pairs per day on six new preparation days	Estimate the daily variance used to size confirmation.

Total cap: 60 valid matched contrasts. The first 48 are search or mechanism exploration; none enters the final variance estimate or confirmation. Keep all attempted runs, qualification failures and excluded records. If a speed or mode cannot qualify, report the missing capability and leave those slots unused unless the matrix is prospectively revised before efficacy data. Do not quietly substitute a favorable speed or reallocate failed cells.

Before the first search contrast, freeze the cell list, day blocks, randomization, geometry revisions, delivery tolerances, and eligibility constraints. Specify a minimum application speed or a laboratory reference-speed requirement before looking at efficacy. A/B uses two speeds selected during qualification, before treatment outcomes, and its own exposure map because removing a collector changes the field and flow.

Default selection rule: among cells meeting the registered flow, metrology, delivery, by-product and reliability requirements, rank the screen by paired log effect d. Advance the top two; ties use lower measured energy per air volume, then a fixed cell identifier. Test each finalist twice per day on three refinement days with balanced orders. Among finalists with positive mean refinement d, select the one with the larger one-sided 90% lower t bound on its mean daily d, calculated from refinement data only. This bound is a ranking device, not a valid post-selection efficacy claim. Ties use lower refinement energy, then cell identifier. If fewer than two cells qualify, test the sole candidate in its original six slots; leave the other slots unused. If no finalist has positive mean refinement d, stop progression within this declared search envelope.

Freeze the selected geometry, polarity or drive mode, exposure, speed, fog composition and wet population, optics and analysis window before the six new variance days. Those days must reproduce the intended confirmation unit. Do not pool different settings or change the selected setting after seeing the pilot variance; an alteration requires a new variance pilot and a documented revision.

Exposure is a vector of local electrical state, particle population, field and residence time. Nominal voltage or supply current alone is not delivered dose. Bipolar emission requires polarity-resolved diagnostics or an explicit device-setting comparison: near-zero net charge can conceal substantial charging. Improvement, no effect and worsening are all retained. These A/B tests concern ionization mechanisms and are not a validated replication of RET’s undisclosed configuration. [S26, S32]

A capacitive or other non-corona system is a candidate architecture, not automatically one of the two interchangeable geometries. Its admission requires a specified design, field-gradient or trajectory qualification, discharge/by-product checks, and a prospectively rewritten matrix suited to its physics. Complete a concrete patent review scope before design commitment; absence of corona alone does not establish freedom to operate. [S27, S28, S29]

6 Fixed confirmation experiment

Freeze a separate version 1.0 before collecting new confirmatory data. Test only D against C at this stage: two randomized C/D pairs per day, with the same collector installed throughout. Each pair contains one powered and one passive run. Use a recorded seed and balanced orders across days; reset between every run. A/B remains a discovery question, which avoids doubling the confirmatory workload and repeatedly changing geometry.

Record at the instruments' native rates. Use time-weighted means in one fixed 300-second downstream analysis window after the qualified treatment-settling interval, with the upstream window shifted by the measured transit lag. Keep a 120-second stable baseline and record the full intervention and recovery. Freeze the spatial weighting and acquisition-gap rules; do not interpolate a missing primary window into existence.

Spread observations across independent preparation days, including cleaning, calibration checks and reassembly checks. Repeated seconds, repeated scans and several trials on one day are not independent days. The two matched collector contrasts are averaged within a day before the primary uncertainty calculation.

Use a fixed, prospectively selected N between 24 and 48 valid independent days. Select the smallest N giving at least 80% modeled power for a planned true 35% extinction reduction while demonstrating more than the 20% usefulness threshold. Require that power under the worst allowed adverse residual bias. These are planning choices, not predictions of efficacy.

For sizing, use the standard deviation of the six selected-setting daily means described in Section 5, with its one-sided 80% upper confidence limit. The log effect for a true 35% reduction is about 0.4308 and the usefulness threshold is about 0.2231. Subtract the bias bound twice from their difference: once for adverse bias in the estimate and once for widening the decision interval. With a bound of 0.05, the planning gap is about 0.1076.

Calculate power with a noncentral t distribution: degrees of freedom N minus 1, noncentrality equal to that planning gap times the square root of N divided by the upper standard-deviation estimate, and the upper critical value for a two-sided 95% interval. Freeze N and the calculation. If no N up to 48 meets the requirement, improve precision or redesign before confirmation. A smaller qualified bias bound can substantially reduce the required sample size.

This sample-size calculation concerns the optical endpoint only. It does not establish 80% joint power to pass optical, energy, reliability and other product gates.

Do not adapt emitter output in response to visibility during confirmation. Ordinary registered flow regulation may remain active in every arm, with its power logged. Evaluate an adaptive visibility controller only after repeatable actuation is established, in a subsequent protocol.

7 Primary endpoint and statistical analysis

For each measurement path, determine extinction from calibrated transmission T and path length L. Extinction is in inverse metres when L is in metres. The bar denotes the time-weighted mean over the registered analysis window. Qualify the optical range for both passive and expected powered conditions; do not replace zero or

out-of-range extinction with an arbitrary small number to make logarithms work. Unresolved censoring requires HOLD or a prospectively revised analysis.

$$\beta = \frac{-\ln(T)}{L}$$
$$R = \frac{\overline{\beta_{down}}}{\overline{\beta_{up}}}$$

For each matched collector pair in a randomized block, compare the passive run C with the powered run D. Positive d indicates improved clearing.

$$d = \ln\left(\frac{R_C}{R_D}\right)$$

Average the two paired d values within each day, then give every valid day equal weight in the overall mean. The reported reduction E is the multiplicative reduction in the upstream-normalized extinction ratio; it is not the arithmetic average of run-level percentages.

$$E = 1 - \exp(-\bar{d})$$

Calculate a two-sided 95% Student t interval for the mean daily d using the observed between-day standard deviation and N minus 1 degrees of freedom. Transform its two endpoints through the same expression for E. Report the raw optical measurements, all daily contrasts, the point estimate and the full interval.

For the decision, widen the log-scale interval on both sides by the qualified residual systematic-error bound. Transform those widened endpoints to a conservative decision interval for E. Identify this separately from the statistical 95% interval; its protection depends on the validity of the systematic-error bound.

The 20% threshold corresponds to a log contrast of approximately 0.2231. Sample-size planning must distinguish that threshold from a larger anticipated effect. Designing merely to reject zero effect would not support a minimum-usefulness claim.

Report the discovery B-against-A results in full, including worsening outcomes. Do not combine them with the new confirmation estimate or promote them to the primary endpoint after observing D against C. Confirmation of H2 requires a separate prospectively specified experiment.

The upstream normalization is valid only when qualification demonstrates that treatment does not alter the inlet measurement or incoming fog state. If that condition fails, redesign the reference measurement before confirmation. Keep the raw upstream and downstream results available so normalization cannot hide that problem.

8 Decision rules and stopping criteria

Publish the numerical optical estimate and intervals separately from the status of metrology, electrical delivery, hardware reliability and product advancement. The 20% threshold is a proposed bench usefulness threshold; it is not yet a validated buyer specification.

Finding	Decision
Lower optical decision bound exceeds 20%	Optical PASS within the tested regime, provided primary metrology and the scheduled-data rules remain valid.

Finding	Decision
Upper optical decision bound is below 20%	Optical FAIL for this proposed usefulness threshold. Report any smaller effect; this is not a universal physical null.
Interval includes 20%, or primary optics are invalid	Optical HOLD. Distinguish insufficient precision from invalid measurement.
Unqualified charge or unresolved spectrum	HOLD the affected mechanism or transfer claim. A verified whole-device optical contrast may remain interpretable.
Treatment-caused primary missingness or a material trip	Retain the fault; reliability fails. Do not erase it through replacement or declare an unconditional optical PASS from surviving runs.
Safety stop or deterioration beyond the registered limit	Stop the setting and retain all records. Resume only after the responsible technical review.
Valid optical PASS plus all frozen product gates	Eligible for the next application stage. Missing buyer limits or unresolved energy, coverage, maintenance or legal requirements keep product advancement on HOLD.

A small repeatable effect may be scientifically informative while failing the proposed 20% requirement. A valid optical PASS does not establish saleable performance or site clearance. A treatment-caused acquisition fault can leave a descriptive estimate among completed runs, but missingness may invalidate the scheduled experiment; report that limitation rather than invent a zero effect.

Independent replication may proceed after a valid optical result with the necessary facility and reliability conditions. Commercial advancement additionally requires prospectively fixed flow, energy, coverage, duty-cycle and maintenance limits. A water-recovery product needs its own yield, water-quality and economic criteria.

9 Secondary outcomes and mechanism checks

For each arm, calculate wall-plug joules divided by actual processed cubic metres over the registered window: integrated power divided by integrated volumetric flow. Report total D energy per volume, total C energy per volume, and their paired difference. If flows differ within tolerance, calculate each ratio using its own measured volume. Also report start-up, standby, recovery and cleaning duty.

State two boundaries: the hardware required by the proposed product, including air-moving power, supply losses and required auxiliaries; and the complete laboratory infrastructure, including artificial fog generation and chamber conditioning. Meter and disclose both. A projected product boundary may exclude apparatus used only to create test fog, but must retain any fan or conditioning load the actual product would need.

Set a buyer-derived energy ceiling before any product advancement test and freeze how uncertainty is treated, preferably using an upper uncertainty bound. An unset ceiling means application HOLD, not erasure of a valid optical result. The 2026 report of about 38.3 Wh/kg is an approximate electrical estimate, not a demonstrated whole-system air-processing benchmark; 30 J/m³ is not an evidence-based acceptance limit. [S25]

Report full wet spectra, size-resolved changes, independent liquid water where available, pressure drop, spatial response and recovery. Keep total collected water separate from the treatment-attributable increment. Water-normalized energy is secondary for a visibility product; do not divide by an unstable, zero or negative incremental water yield.

Close the water balance to qualified accuracy: inlet/outlet liquid water, drain and retained collector water, wall deposition, outlet capture and resolvable vapor change. Include drainage delay and re-entrainment; report the residual. Improved optics without drainage may reflect evaporation or redistribution and does not establish recovered water.

Use measured airflow, thermal and humidity changes to qualify mechanism claims. A remote dummy electrical load checks electronic artifacts but does not reproduce ionic wind or discharge chemistry. For neutral-droplet dielectrophoresis, a spatial field-strength gradient is required for translation; the word capacitive does not define an equivalent dose to corona charging. Register an appropriate exposure model and its limitations for that architecture.

Under spatial homogeneity and an optical measurement qualified for the WMO visible-light convention, meteorological optical range is approximately 3 divided by extinction. Otherwise label the result as a derived monochromatic range at the measurement wavelength. A 20% extinction reduction gives about 25% greater derived range; it does not establish that cleared distance in an open scene. [S4]

10 Records exclusions and blinded review

Record timestamps, run and day identifiers, randomized arm codes, geometry revision, instrument serial numbers, calibration files, native measurements, target settings, actual delivered diagnostics, environment, drainage mass, power, alarms and deviations. Preserve raw records as append-only files with a manifest and cryptographic hashes. Record software versions and the analysis-code hash.

The primary analyst receives coded labels; the operator may know the hardware state. A custodian retains the key and withholds revealing actuator and electrical-diagnostic channels from that analyst. A separate technical reviewer uses those channels for predefined qualification checks. Freeze code, exclusions, run summaries and label-independent plots before decoding. The frozen script then calculates the named D-against-C contrast. This is analyst blinding, not operator blinding.

Accept a run only if its starting state was qualified and at least 95% of the primary window contains valid synchronized optical data. Define sensor fault codes and exposure tolerances before data collection. Do not exclude inconvenient outcomes, strong responses or unexplained residuals. Retain and report every scheduled run.

A treatment-caused C/D fault that invalidates a run remains an operational failure and cannot be erased through replacement. A shared safety hazard stops all testing. Unrelated documented acquisition faults may trigger replacement of the entire C/D pair under blinded rules; a valid day requires two valid pairs. Permit at most 25% additional scheduled days beyond frozen N; otherwise HOLD and report incomplete precision. Do not stop early for favorable efficacy.

Exercise the analysis before sealing it with synthetic null data, a known positive effect, day clustering, missing data, order effects and a large isolated artifact. This checks the analysis pipeline; it does not validate the physics. A reviewer should independently reproduce the primary transformations and decision logic.

The planned reproducibility release should contain the frozen protocol, raw records with data dictionary, calibration summaries, exclusions, analysis code and null as well as positive results. Publication, patent disclosure and third-party data rights need a separate decision before any external release.

11 Facility and legal boundary

Use professionally specified, enclosed, interlocked equipment with rated power supplies, grounding, energy limitation, drainage isolation and fail-safe shutdown reviewed by the responsible facility engineer. This protocol gives no high-voltage construction recipe. It involves no intentional human or animal exposure.

Record numeric voltage/current/energy limits, permitted access, ozone and other applicable by-product limits, ventilation verification and stop settings before energization. An unset critical limit is a HOLD. Select limits from the actual equipment and facility requirements. A non-corona label does not replace discharge and by-product verification.

Before a site pilot, qualify the assembled system for its actual environment: contamination, wet/dry cycling, fouling, drainage, leakage, insulation loss, cleaning recovery, arcing and protective shutdown. Include representative salt exposure for a coastal site. This is a pilot-readiness requirement; basic wet electrical qualification is required before the first energized bench run.

Before execution, record how the specific enclosed apparatus is classified under the selected jurisdiction and facility rules. The intended purpose, physical release boundary and operation matter. An indoor, private-site, visibility or water-recovery description is not itself an exemption.

Federal rules specifically list ion release and electromagnetic radiation when used as weather modification. Where applicable, initial reporting ordinarily must be received at least 10 days before commencement; the local exception is restricted. NOAA reporting is not state authorization. [S5, S6]

Any outdoor experiment needs a separate protocol specifying the affected area, permissions, independent monitoring, stopping authority, downstream effects and liability arrangements. Begin any later application test in an isolated controlled facility. Do not make public-road or operational-port safety depend on an early prototype.

12 Closure register before version 1 is sealed

The design below is reviewable now; these apparatus-dependent entries cannot honestly be invented before equipment and a facility are selected. Close every entry required for the present stage and record reviewer names and dates. Bench execution requires its metrology, design, analysis and facility entries; buyer limits are application-stage requirements and may remain pending during bench work.

Register field	Required content
Facility and classification	Named facility, physical release boundary, jurisdiction analysis, applicable reporting and permits, responsible reviewer.
Hardware and geometry	Drawing revision, dimensions and tolerances, materials, grounding map, collector state and any relevant IP constraints.
Fog state	Generation method, dry-seed chemistry and distribution, wet population including tails, hydration/activation history, liquid water, charge, temperature and humidity limits.
Optical measurement	Wavelength, paths, spatial weights, transit alignment, range, calibration, wet-window checks, bias bound and separate spectral optical-closure tolerance.
Delivered exposure	Architecture, polarity/drive, target measurement and band, spatial/flow map, ion/droplet distinction, bipolar limitation and mode-specific qualification.
Timing	Measured residence time, settling interval, fixed 300-second window, reset criteria and maximum carryover.
Sample size	Exploratory daily variance, upper variance estimate, fixed N from 24 to 48, power calculation and replacement cap.
Assignment and analysis	Random seed and schedule, label custodian, code hash, missingness/exclusion rules and synthetic-analysis checks.
Stops and reliability	Electrical and by-product limits, safety trips, fog-worsening limit, alarm logging and recovery process.
Discovery allocation	Mandatory before bench discovery: exact 60-slot matrix, unqualified-cell rule, eligibility requirements and selection/ranking details.
Application criteria	Required before application advancement, not bench sealing: buyer flow, energy ceiling and uncertainty rule, coverage, duty cycle and maintenance limits.
Review and seal	Independent metrology/statistical review, facility engineering review, final version/date and immutable record location.

Appendix A Proposed weatherhill thesis

weatherhill will test electrostatic methods for controlling airborne water droplets within a defined, instrumented flow or site boundary. The initial product hypothesis is measurable visibility improvement or water recovery at a facility where the air stream, duty cycle and economic value can be quantified. Whether this becomes a viable business remains an experimental and customer question.

Initial application

Start with a contained fog or industrial-plume test section where treated throughput and water destination can be measured. Select one initial endpoint and buyer problem. Ports, road segments and solar farms are prospective markets requiring separate evidence of attainable coverage, operating value and safety; they are not yet validated buyers.

What would be sold

A verified service specification could include extinction reduction across a stated flow, time above an agreed visibility threshold, or recovered water meeting a stated quality requirement. Price and warranties follow demonstrated performance, whole-system cost and maintenance. No rain-volume or regional-weather guarantee follows from WX-FOG-001.

Potential differentiation

The candidate advantage is a measured, transferable relationship between operating state, delivered exposure, geometry and useful outcome, implemented in reliable hardware and control. Geometry matters through droplet trajectories, airflow, field gradients and drainage. Novelty must be established against existing products and patent claims; the words controller and geometry do not confer exclusivity.

Evidence and transparency

Preregister confirmatory endpoints, disclose exclusions and publish null outcomes with sufficient data and code for independent verification. This is an operating discipline, not a guarantee of political acceptance or a unique market position. Decide explicitly which engineering details remain proprietary and which evidence will be public.

Sequence and limits

Qualify measurements, find a stable operating point, run blinded confirmation, obtain independent replication, then test throughput and buyer economics. Pursue a paid controlled-site pilot only after those steps and the site-specific legal review. Rain enhancement and airborne charging remain possible partnership research. Magnets, HAARP/VLF and microwave heating receive no initial development budget because the present evidence does not support this first product.

Appendix B Evidence and commercial corrections

Visibility and open boundaries were already studied

Andreev et al. (2021) report direct optical-density and attenuation measurements in a large fog chamber, using a collector much smaller than the chamber cross-section. Alekseeva et al. (2025) summarize related laboratory and older field experiments, including observations in 2015 and 1993 to 1996. Publication in 2025 is not a new 2025 outdoor replication. The reports motivate controlled benchmarking but do not establish general field performance. [S21, S22]

What the aerosol papers change

The Po Valley measurements show why hydrated aerosol and optical closure matter. The reported 36% is approximately the fraction of in-fog time excluded by adding a liquid-water threshold; it is not a clean attribution of 36% of independent events to one particle class. The 21.3% figure is a median hydrated-particle share of instrument-derived liquid water. The 87% count reduction follows changing the size/activation classification, not removing fog experimentally. Neither this study nor the companion LES work tests an electrostatic collector. [S23, S24]

Energy and flow are still design questions

Ginters and Ginters (2026) describe an approximate 8 to 10 W assessment using assumed conversion efficiency, leading to about 38.3 Wh/kg; a fog-generator fan is described separately. This does not establish measured whole-device energy for processing a known air volume. The reported 19% passive share belongs to the hybrid collected-water decomposition, not a universal incoming-fog capture fraction. [S25]

Illustrative arithmetic only: $38.3 \text{ Wh/kg} \times 3600 \text{ J/Wh} \times 0.0003 \text{ kg/m}^3 \times 0.70$ equals 29 J/m^3 , using assumed 0.3 g/m^3 fog and 70% capture. Those assumptions are not a validated joint operating point. Geometrically, $2000 \text{ m}^3/\text{s}$ at 2 m/s requires 1000 m^2 of face area; it says nothing about bypass or useful cleared coverage. Neither calculation establishes which engineering constraint will dominate.

Charging and the capacitive option

Reading's aircraft result is consistent with changes that could alter fog optics, but it is not a direct demonstration that bipolar treatment has zero effect or that unipolar charging necessarily worsens visibility. ARIA's public schedule describes preparatory monitoring in winter 2026/27 and conditional charge experiments in winter 2027/28. [S26, S31]

Kaindu's 2025 Virginia Tech thesis includes preliminary capacitive collection in a future-work section, reporting a preliminary 2 to 3 times improvement in water-collection efficiency relative to uncharged controls. It supplies no full calibrated visibility/energy validation there. A separate 2025 insulated-electrode paper reports qualitative fog clearing but states that a transmissometer is planned. Both support candidate investigation, not a mandatory architecture choice. [S27, S28]

Patents and existing products

MIT lists its fog-collection technology as exclusively licensed with patents in multiple countries. In US10882054B2, independent claims 2 to 4 do not expressly require corona; corona also appears in dependent claim 23. Removing discharge therefore does not establish a design-around. Conversely, an unspecified weatherhill device cannot be declared infringing. Review an actual drawing and each applicable claim, family, territory and prosecution history. [S10, S29]

Infinite Cooling is a technical and IP benchmark. Its Bugey pilot's announced 1 to 15% recovery was a target, and EDF's April 2026 material describes experimentation. Existing commercial activity does not establish that every improvement is blocked or that audited profitability has been demonstrated. [S11, S12, S13]

RET's filings distinguish a nonexclusive engineering-design license from exclusive plasma-antenna patents it says are not central to rainfall enhancement. Its conference description of FREA identifies corona ionization but does not disclose enough exposure and geometry detail to make Arm B a controlled replication. The announced CHP/Caltrans test through August 2027 is an agreement, not efficacy certification. [S8, S9, S14, S32]

RET finances and the proposed transaction

The June 30, 2026 cash balance was \$32,608; H1 revenue was \$10,500 from an incidental equipment-installation service with no core AEI revenue reported; Q2 net loss was \$3,246,657, and the filing raises substantial going-concern doubt. However, subsequent events include approximately \$2.3 million gross ATM proceeds and \$426,000 borrowing through the filing period. June cash is not October cash, and accounting loss is not cash burn. Treat this as funding and counterparty risk, not a prediction of insolvency or a test of the physics. [S8]

The Tensor Networks LOI was signed September 18 and announced September 23, 2026. The contemplated 90/10 ownership split is before financing dilution; at least \$25 million gross financing and other conditions remain. The announcement retains RET and Tensor as operating subsidiaries. It is not a completed transaction or an announced end to weather research. [S30]

Oman is verified background rather than a first-product dependency

The full July 2026 preprint reports 6.68% estimated attribution with a 95% bootstrap interval of 2.21 to 12.88%, versus 12.52% under its earlier estimator. These estimates concern the analyzed positive-rainfall downwind gauge-day sample, not all Oman rainfall. The paper reuses the 2013 to 2018 trial and shares authorship with earlier work; it is not independent replication. Its comparator is not identical to the marketed roughly 16% headline. [S16]

No raw-data audit has been performed for weatherhill. Published results, access to reusable records and patent rights are different matters. Pursue any future rainfall audit separately; it does not determine the fog experiment. Australian Rain Technologies also states an open-access policy, so transparency requires specific execution commitments rather than an assumption that no competitor offers data access. [S7, S15, S17]

Retain the narrower background conclusions: JST's specific heating/cooling simulations showed precipitation changes of about 0.1% at most; its microwave work ended after FY2025. Reading's 2024 aircraft paper demonstrated charge emission at 3 km, not additional rain. These topics receive no first-product experimental allocation. [S18, S19, S20]

Appendix C Jurisdiction screening

Selected jurisdictions, checked 11 October 2026. This is not a complete legal map. Classify the apparatus and operation: enclosed research, industrial collection or outdoor modification.

State	Verified status	Implication
Tennessee	Public Chapter 709; signed 11 April 2024, effective 1 July 2024. [L1]	Weather-purpose atmospheric release prohibition includes apparatus. No general lab exception was identified in this enactment.
Florida	Chapter 2025-157; effective 1 July 2025. F.S. 403.411 is the enacted provision reviewed. [L2, L12]	Apparatus included; criminal penalties with defendant-specific wording. A visibility label does not establish an exemption.
Louisiana	Act 95 effective 1 August 2025; Act 601 adds a 2026 amendment effective 1 August 2026. [L3, L4]	Current session law matters. The 2026 amendment expressly includes fuel burned in an aircraft engine in the weather-purpose release prohibition.
Iowa	HF2640 passed the House 59 to 26 on 5 March 2026; last substantive listed action is a Senate subcommittee recommendation on 18 March. Status remains Passed House. [L9]	Proposed apparatus prohibition and class D felony are not current law under this bill. [L13] Retain SF2208 as related proposed legislation. [L5]
Illinois	SB2956 last action is referral to Assignments on 27 January 2026. [L6]	Its broad prohibition is proposed text, not an enacted rule.
Colorado	Weather-modification permit framework in 2 CCR 401-1; application generally at least 45 days before activity. [L7]	Novel research is not blanket-approved. Operator qualifications, financial responsibility and public process can apply.
Utah	Utah Code 73-15-3 expressly excludes cloud seeding for fog suppression from its coverage. [L8]	Operation-specific distinction; confirm application to the actual apparatus. Federal duties are separate.
Idaho	S1269 signed 20 March 2026; Session Law Chapter 86, effective 1 July. Adds oversight and reporting requirements. [L10]	Counterexample to the claim that only Louisiana enacted a 2026 law. Fog dispersal is excluded from this chapter, not from all other law.

RET reports a Colorado permit obtained 29 October 2025. An issued Utah permit and current renewals were not established here. An announcement or application does not establish authorization. [S9]

Federal reporting workflow when applicable

Determine 15 CFR 908 applicability before operation. Record operators, sponsors, target/control areas, equipment, dates and safeguards. Unless a specified exception applies, initial notice must reach NOAA at least 10 days before commencement. File applicable interim reports and a final report within 45 days. Keep required records, including changes, for three years. NOAA reporting is not operating approval. [S5, S6]

Continuing-project interim reports are generally due 45 days after January 1. State exceptions and small footprints do not automatically remove federal duties. [S5]

GAO-26-108013 (23 February 2026) found widespread likely report errors and recommended written review guidance, clearer instructions for completing forms and outreach. NOAA agreed; all three recommendations remained open when reviewed. Add a report-quality check. This audit is not legislation or authorization. [L11]

Appendix D Decisions on the proposed amendments

This disposition supersedes the proposed R1 to R8 wording for weatherhill. It incorporates useful changes without accepting unsupported novelty, energy, company or legal claims. References and reasoning appear in the main sections and Appendix B.

Proposal	Decision and implementation
R1 Full span and bypass	Retain D/C as primary. Define later H3 for spatial benefit, bypass and replenishment. Prior open-boundary work exists; the question is the performance of this design.
R2 Size and optical weighting	Adopt with wet-state qualification and bounds on both missing tails. Report net spectral changes and modeled optical weighting separately from measured water capture.
R3 Seeded fog	Replace the blanket rejection of ultrasonic fog. Use it for qualification or a limited apparatus claim; confirm any natural-fog claim in a representative characterized regime.
R4 Air speed	Adopt with the explicit 24 + 12 + 12 + 12 allocation. Qualify proposed 1, 2 and 4 m/s before use. Record unavailable conditions and do not silently recycle cells.
R5 Energy gate	Adopt measured joules per processed cubic metre for product decisions. Discard 30 J/m ³ as a validated anchor. Keep physical optical findings separate from buyer-derived advancement gates.
R6 Bipolar emission	Include within the 12 exploratory A/B slots if qualified. Permit either optical direction and measure exposure appropriately. Do not claim a RET replication.
R7 Capacitive design	Keep as a candidate architecture requiring its own qualified exposure model and matrix. Do not reserve half the geometry budget before technical and patent review.
R8 Reliability	Adopt before the relevant site pilot, with salt exposure when appropriate. Basic wet electrical safety remains a prerequisite to bench energization.

Appendix updates: add HF2640, Idaho S1269 and the GAO audit; qualify RET finances and transaction status; replace the unresolved Oman abstract summary with verified full-text estimates. These corrections do not require the bench experiment to wait for a rainfall audit.

Appendix E Facility selection and capability request

Recommendation: prioritize a technical feasibility discussion with TROPOS LACIS-T, with Michigan Tech as a U.S. scientific alternative and Cerema as a visibility-validation option. Select a facility only after written integration, access and cost answers. No facility has been contacted or booked for this protocol.

Facility	Documented fit	Integration question
TROPOS LACIS-T Leipzig, Germany	Seeded moist-air wind tunnel; published measurement section $2 \times 0.8 \times 0.2$ m, speeds 0.5 to 2 m/s, and hydrated-particle/droplet measurements with an approximately 300 nm instrument detection limit. [F1, F2]	Can it support full-span collection, sufficient direct optical paths, electrical integration and stable fog with the added blockage? 4 m/s is not established.
Michigan Tech Pi Chamber Houghton, U.S.	Controlled aerosol/cloud states, sustained clouds and optical-propagation research. [F3]	It is a convection chamber, not a ready 1 to 4 m/s collector duct. Determine throughflow integration, wet-size coverage and current company access terms.
Cerema PAVIN Météo Extrême Clermont-Ferrand, France	50 m covered platform for external product and sensor evaluation; stated stabilized MOR 10 to 80 m. [F4]	Confirm representative seeded fog, instrumentation, treatment integration and flow. Strong candidate for later visibility and partial-span validation.

Reading is a relevant collaborator for charge measurement and interpretation. Its public BrightSpark material does not establish a bookable facility meeting this complete test. Published access pathways at candidate laboratories do not guarantee a current slot, subsidy, industrial eligibility or acceptance of high-voltage equipment. [F5]

Reviewable inquiry scope

Supply the facility with this protocol and a preliminary collector drawing. Ask for a written response against the following capability and cost requirements. These are inquiry contents, not messages already sent.

Requirement	Requested evidence or answer
Fog and particles	Reproducible dry-seed chemistry and size; wet aerosol/droplet spectrum, activation/hydration history, humidity stability and measurement of extinction-relevant tails.
Optics and flow	Two direct extinction paths with sufficient sensitivity; spatial mapping and transit alignment; actual section dimensions, face velocities, pressure capacity, bypass and collector blockage effects.
Electrical integration	Accepted architecture and enclosure; charge or field-gradient diagnostics; measurement artifacts, discharge products, grounding, drainage and responsible engineering review.
Reset and scheduling	Demonstrable clearance of charge, wet films and fog carryover. Quote qualification separately, then discovery, six fresh variance days and conditional confirmation of 24 to 48 independent days.
Terms and responsibilities	Installation and staff costs, calibration, access eligibility, timing, data ownership, publication/IP terms, label custodian, independent review and site-specific legal classification.

First contractual milestone, if subsequently authorized: demonstrate measurement bias, spatial/flow validity, a stable fog population and reproducible reset with the inserted apparatus. Do not commit to a full confirmation campaign until that result and the selected-setting variance support it.

Bounded patent review scope

Prepare one drawing and operating description for each candidate architecture, including field generation, collection surfaces, spacing, insulation, flow path and intended market. Ask counsel for a jurisdiction-specific claim analysis of the MIT/Infinite Cooling families, relevant continuation and national-phase claims, and non-corona or mesh-geometry prior art. Request identified blockers, design options and unresolved applications rather than a generic sector search. This protocol has not commissioned that review. [S10, S29]

References

Primary research, official facility descriptions, company disclosures and legal sources reviewed for this revision on 11 October 2026. Source numbers identify support; draft design thresholds and team recommendations are explicitly proposed. A patent or pilot announcement is not independent efficacy evidence. Historical references retained from version 0.1 are supplemented by the new audit.

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- [S3] Spiegel et al. Evaluating the capabilities and uncertainties of droplet measurements for the fog droplet spectrometer FM-100. *Atmospheric Measurement Techniques* 5, 2237-2260 (2012).
- [S4] WMO OSCAR. Meteorological Optical Range surface variable definition.
- [S5] 15 CFR Part 908. Maintaining Records and Submitting Reports on Weather Modification Activities.
- [S6] NOAA. Fact check Debunking weather modification claims.
- [S7] Chambers, Beare, Peak and Al-Kalbani. Nudging a Pseudo-Science Towards a Science. *International Statistical Review* 90, 346-373 (2022); Data S1 link listed.
- [S8] RET. Form 10-Q for the quarter ended 30 June 2026. Engineering-design license disclosure.
- [S9] RET. Form 10-K for the year ended 31 December 2025, filed 2026. Intellectual Property; IP risk factors; Note 6.
- [S10] MIT Technology Licensing Office. Enhanced Fog Collection with Corona Discharge, case 18026.
- [S11] Infinite Cooling. WaterPanel plume-abatement product page. Company description.
- [S12] Infinite Cooling and EDF. Water conservation pilot announcement, 24 September 2024.
- [S13] EDF. Facts and Figures 2025, April 2026 edition, page 20.
- [S14] RET. Agreement with California Highway Patrol to test fog mitigation technology, 1 September 2026. Company announcement.
- [S15] Australian Rain Technologies. Resources and stated open-access policy.
- [S16] Tho, Chambers and Welsh. Bias-Adjusted Attribution Estimation for Rainfall Enhancement Trials. arXiv 2607.21991v1 (24 July 2026), Section 5 and Table 3. Full HTML and PDF retrieved.
- [S17] Statistical Society of Australia. NSW Branch Annual Dinner 2018 report of Chambers lecture.
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- [S21] Andreev et al. Results of Experimental Studies on the Dispersal of Warm Fogs Using Gauze Electrostatic Precipitators. *Russian Meteorology and Hydrology* 46, 716 to 721 (2021). Author full text reviewed.

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- [S27] Kaindu. Advanced Fog Harvesting Techniques. Virginia Tech dissertation (9 June 2025), printed pages 75 and 76, future work.
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- [F4] Cerema. Plateforme Pavin Météo Extrême, current product-testing service description.
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- [L2] Florida Legislature. F.S. 403.411, enacted in 2025.
- [L3] Louisiana Legislature. SB46 of 2025, Act 95, bill history.
- [L4] Louisiana Legislature. SB189 of 2026, Act 601, bill history.
- [L5] Iowa Legislature. SF2208 official history, 91st General Assembly.
- [L6] Illinois General Assembly. SB2956 official status, 104th General Assembly.
- [L7] Colorado Secretary of State. 2 CCR 401-1 Weather Modification Rules and Regulations.
- [L8] Utah Legislature. Utah Code, Title 73, section 73-15-3.
- [L9] Iowa Legislature. HF2640 official history, 91st General Assembly; House passage and Senate actions.
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- [L11] U.S. Government Accountability Office. GAO-26-108013, Weather Modification, 23 February 2026.
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