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Physical Climate Risk for Manufacturing Assets: Hazard Taxonomy & Thresholds

QUICK FIELD REFERENCE CARD
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https://bcesg.org/physical-climate-risk-manufacturing-assets/

CORE OPERATING PRINCIPLE: ASSET-LEVEL RESOLUTION & HYPER-LOCAL MICRO-GEOGRAPHY

Portfolio screening in broad regional bands fails IFRS S2, ESRS E1, and California SB 261 standards. Credible diligence requires facility-level coordinate mapping at **~0.05° grid resolution (≈5 km)**. Micro-geography decides physical outcomes: two manufacturing plants in the same river basin can sit meters apart in elevation and entire categories apart in flood or storm surge exposure.

1. CMIP6 PLANNING HORIZONS & DECISION MAPPING

Horizon	Planning Window	Decisions Informed (Scenarios: SSP1-2.6, SSP2-4.5, SSP5-8.5)
Near term	**2026–2030**	Operating budgets, parametric and property/BI insurance placement, immediate supply-chain resilience buffers, filter changeout cycles.
Medium term	**2031–2040**	Mid-life plant upgrades, chiller/cooling tower re-engineering, adaptation CapEx sequencing, dual-region supplier qualification.
Long term	**2041–2060**	Useful-life and depreciation policy (IAS 36/ASC 360), greenfield plant siting, structural elevation, terminal value assumptions in DCF models.

2. HAZARD TAXONOMY: ACUTE EVENTS VS. CHRONIC DRIFT

ACUTE HAZARDS — Arrive as discrete destructive events

- **Pluvial & Fluvial Flooding:** Riverine overtopping and surface pooling evaluated at 100-yr and 500-yr return periods against plant equipment elevations.
- **Tropical Cyclones & Surge:** Category 4/5 sustained wind fields plus coastal surge height above mean sea level (MSL) testing roof, cladding, and outdoor tanks.
- **Wildfire & Particulate Smoke:** Wildland-Urban Interface (WUI) direct perimeter threat plus regional smoke episodes forcing cleanroom filtration trips and plant stops.

CHRONIC STRESSES — Arrive as compounding physical drift

- **Wet-Bulb Heat (Tw):** Combined ambient heat and humidity driving severe labor productivity declines and thermodynamic failure of evaporative cooling systems.
- **Baseline Water Stress (BWS):** WRI Aqueduct ratio of water withdrawals to renewable local supply, driving municipal allocation cuts, rationing, and tariff jumps.
- **Thermal Efficiency Degradation:** Continuous physical derating of gas turbines, chillers, cooling towers, and steam generation as ambient temperatures rise.

3. QUICK-REFERENCE PHYSICAL DAMAGE & OPERATIONAL THRESHOLD VALUES

Hazard / Metric	Threshold Value	Operational Mechanism & Damage Consequence
Flood Inundation Depth	**~0.5 m (20 in)**	Reaches sub-fab conduits, floor-mounted switchgear, control panels, electrical substations, and pump motors. Short-circuit risk.
Flood Inundation Depth	**~1.5 m (59 in)**	Physical displacement of heavy machinery, chemical reaction vessels, CNC lines; structural racking; prolonged total facility shutdown.
Wet-Bulb Temperature (Tw)	**Low-30s °C**	Human labor productivity drops steeply; cooling tower approach margins collapse; cleanroom electronics trip on condensing humidity.
Physiological Survivability	**35.0 °C Tw**	Theoretical upper physiological limit for sustained metabolic heat dissipation; unmitigated human occupancy is non-survivable.
Baseline Water Stress (WRI)	**> 40% (High)**	Water withdrawals exceed 40% of renewable supply; municipal curtailment orders during dry seasons; initial water tariff surcharges.
Baseline Water Stress (WRI)	**> 80% (Extreme)**	Critical rationing, intake quotas, mandatory closed-loop recycling CapEx; production throttling in fabs, pharma, and beverage plants.
Gas Turbine Derating	**0.5% – 0.7% / °C**	Loss of electrical/shaft output for every 1°C above 15°C ISO base rating. Chillers, cooling towers, and steam boilers derate on same physics.
Extreme Dry-Bulb Heat	**Days > 40 °C**	Chiller energy demand surges; polymer resin and precision metal parts warp outside tolerances; regional power grids trip offline.
Tropical Wind & Surge	**Cat 4/5 + Surge > MSL**	Envelope cladding loss, roof tearing, outdoor tank floatation/displacement, saltwater corrosion of mechanical control infrastructure.

4. ASSET VULNERABILITY MATRIX (PAGE TABLE SPECIFICATION)

Hazard	Working Metric	Assets Most Exposed	Operational Failure Mechanism
Pluvial/fluvial flood	Peak depth at 100-yr return	Fabs, automotive assembly	Sub-fab equipment inundation; cleanroom loss; short circuits; prolonged recertification downtime.
Wet-bulb heat	Consecutive days in low-30s °C Tw	Heavy industry, textiles, outdoor refining	Severe labor capacity loss; mandatory rest cycles; cooling-tower thermodynamic derating; electronics trips.
Water stress	Aqueduct BWS (>80% = extreme)	Pharma, wafer processing, beverages	Municipal intake rationing; expensive recycling CapEx; direct plant volume throttling.
Storm surge	Surge height above MSL	Coastal chemicals, port terminals	Accelerated saltwater corrosion; chemical storage tank displacement; multi-week maritime shutdown.
Thermal shift	Days above 40°C dry-bulb	Precision machinery, plastics	HVAC and cooling energy cost surge; raw polymer warping; tight tolerance failures; grid brownouts.

5. CRITICAL FAQ DISTINCTION: WET-BULB (TW) VS. WBGT

Wet-Bulb Temperature (Tw) — Thermodynamic Metric

- **Definition:** The lowest temperature achievable by evaporative cooling of a wetted surface at ambient pressure and airflow.
- **Governs:** Cooling tower heat dissipation, chiller efficiency, and the **35°C physiological survival limit** for metabolic heat dissipation.
- **Application:** Industrial process design, cooling plant sizing, and macroeconomic labor capacity modeling.

WBGT (Wet-Bulb Globe Temp) — Occupational Standard

- **Definition:** Composite index combining natural wet-bulb temperature, black globe radiant heat temperature, and ambient dry-bulb air temperature.
- **Governs:** Mandatory OSHA/ISO worker work/rest regimes, hydration breaks, and labor shift limits in direct sunlight or radiant work environments.
- **Auditor Rule:** Tw and WBGT are related but *not interchangeable*. Conflating them distorts plant labor downtime models.

6. CATASTROPHE-MODELLING EAL IDENTITY & VALUATION RULES

THE CAT-MODELLING IDENTITY: EXPECTED ANNUAL LOSS (EAL)

$$EAL = \sum_{hazards} \int [\ Probability(h) \times Vulnerability(h) \times Exposed\ Value\ ]\ dh$$

- **Probability(h):** Derived from 100-yr/500-yr local exceedance probability curves under SSP1-2.6, SSP2-4.5, and SSP5-8.5.
- **Vulnerability(h):** Asset-specific damage function curve (e.g., semiconductor cleanroom vs. steel staging warehouse).
- **Exposed Value:** Full physical asset replacement cost plus net gross margin supported by that specific asset line.

DCF & Impairment (IAS 36 / ASC 360)

- **Free Cash Flow Deduction:** EAL enters cash flows as an annual deduction, alongside justified adaptation CapEx.
- **Shortened Useful Life:** Chronic thermal and water stress accelerate plant depreciation and reduce terminal value.
- **Impairment Indicator:** Stranding triggers when required retrofit CapEx exceeds remaining discounted cash flows.

Auditor Discipline: Zero Double-Counting

- **The Double-Count Trap:** Never add a blanket "climate risk premium" to WACC if EAL is already deducted in cash flows.
- **Auditor Defense:** WACC adjustments are defensible *only* for unmodelled residual systemic risk.
- **Audit File Standard:** Auditors require raw engineering damage curves and derating schedules, not narrative summaries.