HUIJUE GROUP

Electrical Enclosure Heat Load Calculation for Telecom Sites

Calculate a telecom enclosure’s steady heat load from equipment losses, cabinet surfaces, solar exposure and airflow, then test the assumptions before cooling selection.

PRODUCT KNOWLEDGE

Electrical Enclosure Heat Load Calculation for Telecom Sites

Calculate the heat that must leave a telecom cabinet from actual equipment losses, enclosure surfaces, solar exposure and air exchange—then test every assumption before selecting cooling hardware.

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Contents
 A 6 kW rectifier is not automatically a 6 kW cabinet heat source. If it delivers useful DC power to loads outside the thermal boundary, only its conversion loss and locally dissipated auxiliaries heat that enclosure. Treating the full nameplate as heat can oversize cooling dramatically; ignoring conversion, cable, battery-recharge and solar effects can produce the opposite error.The purpose of an **electrical enclosure heat load** model is therefore not to add every electrical rating on a bill of materials. It is to trace energy across a precisely defined cabinet boundary for stated operating conditions. The answer is a thermal duty in watts, accompanied by the temperatures, equipment states and uncertainties that make that number valid.

This guide presents a steady-state screening method suitable for design review and supplier comparison. It does not replace configuration-specific thermal simulation, equipment loss data or testing of the populated cabinet. All numbers in the worked example are illustrative and are not Huijue product ratings.

What does an enclosure heat-load calculation determine?

It determines the net rate of heat that the cabinet must reject, at a declared internal condition and operating case, to avoid a continuing temperature rise. It does not by itself prove component temperatures, cooling reliability, moisture control or time to overtemperature after a cooling failure.

Define four outputs before opening a spreadsheet:

1. **Protected condition:** the relevant inlet-air, battery, terminal or other project-defined temperature—not an arbitrary cabinet average.
2. **Operating case:** normal traffic, peak traffic, battery recharge, source transition, future load or an agreed degraded condition.
3. **Net thermal duty:** heat generated inside plus heat crossing the boundary, with every term following the same sign convention.
4. **Validation requirement:** the simulation, chamber test, FAT measurement or field trend that will be compared with the calculation.

The allowed internal condition comes from the most restrictive installed item and the required service outcome. A battery may impose a different temperature window from rectifiers or radio equipment. A cable termination can become locally hot even while the measured air remains acceptable. Derating, charging limits and alarm thresholds should be taken from approved manufacturer data for the exact equipment revision.

Do not begin with the cooling-unit catalogue

A catalogue rating cannot define the duty it is supposed to meet. First establish the cabinet boundary, the internal losses and the environmental cases; then compare the required duty with declared cooling performance at the same indoor and outdoor conditions.

Set the calculation boundary before collecting watts

Draw one line around the air volume and surfaces represented by the calculation. Mark every electrical, thermal and airflow path that crosses it. A single-shell cabinet, an equipment compartment and an isolated battery compartment are three different models even when they share one product name.

Boundary item	Question to close	Common error
DC output	Does useful output power leave the modelled enclosure?	Counting the full rectifier input and then also counting load heat
Remote radio or antenna unit	Is its heat inside this cabinet or outdoors at the point of use?	Adding a remote load to cabinet heat because it appears on the site load list
Cooling unit	Which side contains its evaporator, condenser, motors and controls?	Adding all cooling electrical input as internal heat even when heat is rejected outside

Boundary item	Question to close	Common error
Battery zone	Is battery heat released into the same controlled air volume?	Combining thermally isolated compartments without an interface term
Vents and leakage	What air intentionally or unintentionally crosses the boundary?	Using a sealed-cabinet equation for a filtered ventilation design
Walls, roof and door	Which areas see shade, sun, ground reflection or another warm surface?	Applying one temperature and one U-value to every face

The site electrical diagram and the thermal diagram should agree. The telecom power cabinet versus equipment cabinet guide helps assign loads and interfaces when power and ICT functions occupy separate or shared enclosures. If a feeder crosses the thermal boundary, record both the useful electrical power that leaves and the losses that remain inside.

How should internal equipment heat be calculated?

Use measured or manufacturer-declared loss at the actual duty whenever it is available. If only output power and efficiency are known, calculate the difference between input and useful output. Nameplate capacity is a limit, not a loss value.

Conversion equipment loss

$Q_{loss} = P_{in} - P_{out}$

$Q_{loss} = P_{out} \times (1 / \eta - 1)$

Q is heat released inside the selected boundary in watts; η is efficiency as a decimal at the stated load, input condition and temperature.

For a 4,000 W DC output at 95% efficiency, the calculated conversion loss is about 211 W, not 4,000 W and not 4,211 W. If the efficiency falls to 92% at another duty or temperature, the loss rises to about 348 W. That difference belongs in the operating-case comparison.

Build the **equipment heat dissipation** schedule line by line:

- **Rectifiers, inverters, MPPT controllers and DC/DC converters:** use loss maps or efficiency at the simultaneous operating point, including standby modules where material.
- **Telecom and network equipment:** if electrical energy enters and no useful energy leaves the cabinet in another material form, nearly all input ultimately becomes heat; confirm any powered outdoor or remote load is outside the boundary.

- **Batteries:** separate standby, discharge and recharge states; use chemistry- and current-specific heat data rather than assuming a fixed percentage.
- **Conductors, busbars and terminals:** include material I^2R losses at the relevant current and temperature, especially on high-current battery and DC paths.
- **Fans, heaters, lights, contactors and controls:** include their internal dissipation only when operating in the case being modelled.

Redundant equipment requires care. An N+1 rectifier shelf may share load across more active modules, changing efficiency and individual hot spots. A standby module may consume only a small amount until another module fails. Model the normal sharing case and the credible module-out case separately instead of multiplying rated loss by the installed module count.

Cooling electrical input also needs an energy boundary. The internal fan motor normally adds its input as cabinet heat. For a split refrigeration path, the evaporator fan and some controls may be inside while the condenser rejects heat outdoors. Adding the complete air-conditioner input to the internal heat load and then asking the same unit to remove it can double-count energy. Follow the manufacturer’s declared test boundary.

Calculate heat through the cabinet walls and solar boundary

Heat crosses each cabinet surface according to its effective thermal transmittance, area and temperature difference. Treat the term as signed: it adds heat when the exterior-side equivalent temperature is higher than the protected interior condition and removes heat when it is lower.

Surface heat-transfer screening term

$$Q_{surface,i} = U_i \times A_i \times (T_{eq,i} - T_{in})$$

U is effective transmittance in W/m²K, A is exposed area in m², and T_{eq} represents the exterior thermal condition for that face. Positive Q enters the cabinet.

Use face-by-face data when roof, sun-facing wall, shaded rear, door-mounted equipment and base have different constructions or exposures. An empty enclosure’s nominal U-value may not represent thermal bridges, vents, cable plates, door hardware or a mounted cooling unit. Double-wall construction and solar shields change the boundary, but their benefit should come from tested data or a justified model for the offered assembly.

Cabinet solar gain can be represented through a validated equivalent exterior temperature, a surface absorptance and irradiance model, or configuration-specific testing. Do not add both a full solar-gain term and a sol-air temperature that already includes solar effects. ETSI ES 203 156 states that solar radiation should be considered during cabinet development and notes solar shielding as one available response. Its framework also asks suppliers for geometry, airflow and thermal characterization data. See the official ETSI standard for the defined scope and conditions.

The single-wall versus double-wall cabinet guide owns the construction decision. In this calculation, use the thermal property and surface geometry resulting from that decision; do not assume that the words “double wall” supply a universal U-value.

How does ventilation change the heat balance?

Air exchange carries sensible heat into or out of the enclosure according to airflow, air properties and the outdoor-to-indoor temperature difference. It can reject heat when outdoor air is cooler than cabinet air, but it becomes a heat gain when the outdoor air is hotter than the protected condition.

Sensible heat carried by air

$$Q_{air} = \rho \times c_p \times \dot{V} \times (T_{out} - T_{in})$$

ρ is air density in kg/m³, c_p is specific heat in J/kgK and $\dot{V}$ is actual volumetric flow in m³/s. Positive Q enters the cabinet under this sign convention.

A **cabinet airflow calculation** must use delivered flow at the installed resistance, not the fan’s free-air label. Filters, louvres, rain paths, grilles, shelves, cable bundles, altitude and fouling change the operating point. Use the fan curve and the system pressure-drop curve, then check that supply reaches the equipment inlets without bypass or recirculation.

This sensible equation does not prove dust, salt, humidity, condensation or water control. Those are parallel design constraints. If outside air is unacceptable, setting $\dot{V}$ to zero may represent the intentional ventilation term for a sealed cabinet, but leakage and service-door conditions still need appropriate review.

Build one equation for each operating case

There is no single “maximum” case until the simultaneous equipment, charging, environmental and cooling states are defined. Build a case matrix and calculate each row. The design owner can then see which assumption drives the result rather than hiding every uncertainty inside a blanket margin.

Steady-state cabinet heat balance

$$Q_{case} = \Sigma Q_{internal} + \Sigma Q_{surface} + Q_{air} + Q_{other}$$

$Q_{required} = \max(0, Q_{case})$

$Q_{required}$ is the net heat-removal duty at the declared protected condition. A zero result does not prove safe temperatures or adequate internal air distribution.

Case	Equipment and battery state	Environmental boundary	Why it can govern
Normal busy hour	Representative telecom load and normal conversion sharing	Seasonal operating ambient and solar condition	Establishes continuous duty and energy consumption
Hot recovery	Live load plus post-outage battery recharge	High ambient and afternoon solar exposure	Conversion and battery losses can coincide
Growth	Approved future equipment population	Same declared hot boundary	Empty rack space may conceal insufficient thermal reserve
Cooling degraded	Critical loads retained; one fan/module/mode unavailable	Agreed credible ambient condition	Tests redundancy, derating and response time
Cold or low load	Minimum dissipation, charger standby and heater state	Low ambient with humidity condition	Can govern condensation, battery charging and heater duty

Keep margin visible. If equipment loss tolerance, future load, surface property, fouling and climate uncertainty are all material, represent them as named cases or line items. A single undocumented percentage makes it impossible to know what has already been covered and what still needs confirmation.

Worked example: a sealed outdoor telecom power cabinet

Consider a hypothetical sealed enclosure. The project wants a 35°C protected internal reference under a 45°C design ambient. Some faces are shaded; a smaller sun-exposed area is represented by a 58°C equivalent exterior temperature. The effective surface transmittance used for this screening calculation is 0.75 W/m²K. These are assumptions for the example, not recommended setpoints or Huijue data.

Internal item	Assumption	Heat inside boundary
Rectifier conversion	4,000 W useful DC output at 95% efficiency	210.5 W
Telecom and control equipment	Approved heat schedule for the stated traffic case	240 W
Distribution and conductors	Calculated and declared local losses	35 W
Battery recharge and auxiliaries	Heat released in this compartment during the case	80 W
Internal fans and controls	Electrical input dissipated inside	20 W
Internal subtotal	Sum of simultaneous entries	**585.5 W**

The shaded effective area is 3.4 m². Its contribution is 0.75 × 3.4 × (45 − 35) = 25.5 W. The solar-exposed effective area is 1.8 m². Its contribution is 0.75 × 1.8 × (58 − 35) = 31.1 W. With no intentional air exchange in this sealed case, the calculated total is:

Illustrative result

Q_{case} = 585.5 + 25.5 + 31.1 + 0 = 642.1 W

The result is the estimated steady net heat-removal duty for this exact case before unresolved uncertainty, future-load allowance or a technology-specific rating check.

Do not round 642 W into a product selection yet. First check whether all losses are simultaneous, whether the protected point should be 35°C, whether the surface model represents the complete assembled cabinet, and whether the cooling product's declared capacity uses compatible indoor and outdoor conditions.

Which assumption changes the result most?

The answer depends on the configuration, so vary one defensible input at a time. In this example, rectifier efficiency and added equipment load change the result more than a five-degree adjustment to the protected air reference. Another cabinet with a dark unshielded roof or high air leakage could be dominated by the boundary instead.

Variation from base case	Recalculated duty	Engineering interpretation
Base assumptions	642 W	Comparison point only
Rectifier efficiency is 92%, not 95%	779 W	Loss rises by about 137 W; obtain the correct efficiency map
Future installed equipment adds 150 W of heat	792 W	Rack and power reserve do not guarantee thermal reserve
Protected reference is 40°C and every component permits it	623 W	Boundary gain falls, but equipment life and battery limits still govern

Repeat the exercise for solar equivalent temperature, U-values, airflow, filter loading, cable losses and battery recharge. The sensitivity table becomes a request list: inputs that materially change the answer deserve stronger manufacturer data, measurement or test evidence.

A published study of a telecommunication radio base station found that equipment heat, outdoor temperature and solar radiation contributed to substantial internal-to-external temperature differences, especially during warm daytime conditions. The study also reported that wall transmittance, reflectivity, ventilation and setpoints changed energy behaviour. It supports treating these as variables, not universal constants; see the paper record and abstract.

Can a heat exchanger meet the calculated load?

Only if its declared cooling capacity at the relevant temperature difference equals or exceeds the duty and its installed airflow protects the limiting components. A sensible air-to-air exchanger cannot maintain the cabinet below the available outdoor heat sink without another cooling mechanism.

ETSI defines enclosure cooling capacity CC in W/K from equipment heat dissipation divided by the internal-inlet to ambient temperature difference. Rearranged as a screening check:

Heat-exchanger capacity check

$Q_{available} = CC \times (T_{inlet} - T_{ambient})$

Use the manufacturer's CC at the stated ambient and fan condition. This relationship applies when the cabinet is warmer than the outdoor heat sink.

For example, a hypothetical 75 W/K enclosure at a 10 K internal-to-ambient difference corresponds to 750 W under the declared conditions. At zero temperature difference, that sensible transfer mechanism has no positive differential to drive the same heat out. This is why a W/K label cannot be compared directly with the 642 W worked result without reconciling temperatures, boundary terms and test definitions.

The broader telecom cabinet cooling guide owns the choice among passive transfer, filtered ventilation, closed-loop heat exchange and refrigeration. A later article will address the narrower question of when active cabinet air conditioning is required. This page supplies the heat-load evidence those decisions need.

Validate the spreadsheet against the populated cabinet

A calculation is ready for use only when every important input is traceable and its predicted temperatures can be checked against the offered configuration. Steady-state balance is particularly weak at predicting local hot spots, airflow short circuits and time to a limit after cooling stops.

The final **cooling capacity calculation** pack should include:

- cabinet and compartment drawing with areas, constructions, openings, equipment positions and thermal boundaries;
- equipment loss schedule tied to model, revision, operating state, input voltage, load and temperature;
- site design ambient, solar method, mounting geometry, altitude and air-quality assumptions;
- case matrix showing normal, recharge, growth, low-load and agreed degraded states;
- cooling performance at compatible rating conditions, including airflow, pressure resistance, fouling and auxiliary input;
- predicted component-inlet, battery and other limiting temperatures—not only

one average air value;
- FAT or thermal-test procedure with load representation, sensor map, calibration, stabilization rule and pass limits;
- comparison of predicted and measured values, followed by controlled correction of the model where they differ.

Transient evidence is separate. If the project requires the site to remain in service for a defined time after fan, exchanger or air-conditioner failure, measure or simulate temperature rise with the agreed thermal mass, load and outdoor boundary. Do not infer that time from a steady-state watt figure.

A useful spreadsheet exposes uncertainty

Show units, sources, sign conventions, formulas and revision dates. Protect formula cells if needed, but do not hide them. A reviewer should be able to change efficiency, load, area, solar condition or airflow and see exactly which case and temperature requirement moves.

Engineering boundary

This method does not prescribe a Huijue cabinet model, equipment population, cooling type, capacity, airflow, temperature, margin or acceptance result. Final design requires the approved bill of materials, manufacturer loss and thermal data, site conditions, destination requirements and verification of the populated cabinet.

Turn the cabinet equipment list into a reviewable heat balance

Send the enclosure drawing, compartment boundaries, equipment and loss schedule, operating cases, allowable temperatures, site ambient and solar basis, airflow restrictions and future-load plan. Huijue can develop a project-specific heat balance, cooling boundary and verification scope for engineering review.

Submit cabinet thermal inputs

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