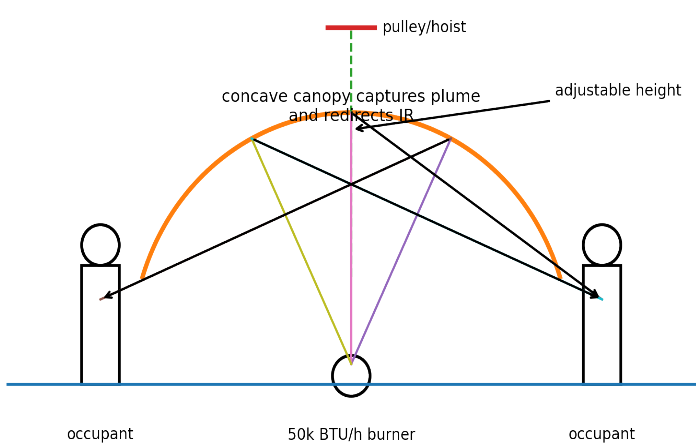
High-Efficiency Patio Fire Pit Concept
Adjustable Radiant Canopy for 'More Warmth per BTU'

Design + physics notes for propane/natural gas/wood fire pits (example math assumes 50,000 BTU/h natural gas burner).



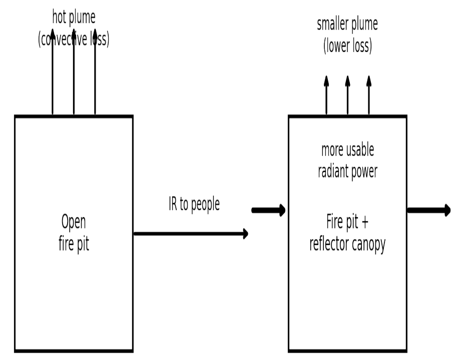


Figure 1. Adjustable concave canopy redirects infrared (IR) toward the occupied zone; Figure 2. Convert 'lost plume' into usable radiant heat.

Outdoors, **convection is a poor heater** because warm air is quickly replaced by wind and buoyant mixing. What occupants feel most strongly is **thermal radiation** (mid-IR, roughly 3-14 µm) absorbed by skin and clothing. Efficiency here means: **increase the fraction of burner heat that becomes directed IR to occupants**.

Core physics

(1) Capture plume energy long enough to heat a shaped canopy, then **(2) use geometry (view factor) + surface properties** to send that energy into people instead of the sky.

Design levers that increase perceived warmth per BTU

Radiant fraction: add a canopy that becomes a hot radiating surface and/or redirects flame IR. **View factor (geometric coupling):** lower canopy height and a flared rim increase canopy-to-people coupling. **Specular reflection:** a polished, low-emissivity liner redirects IR by reflection (angle in = angle out) without needing thick mass. **Convective loss control:** stabilize the flame and slow the vertical jet with a wind shroud, perforated skirt, or glass guard. **Thermal mass (optional):** improves "afterglow" and comfort stability, but slows warm-up and adds weight/handling requirements.

Power: $\dot{Q}_{in} = 50{,}000\ \text{BTU/h} = 14.65\ \text{kW}$

Radiation from a surface: $q'' = \varepsilon\,\sigma\,(T_s^4 - T_{amb}^4)$

Power to people: $\dot{Q}_{people} \approx F_{s\to p}\,A_s\,\varepsilon_s\,\sigma\,(T_s^4 - T_{amb}^4)$

Geometric leverage: maximize view factor $F_{s\to p}$ using canopy height + flare angle.

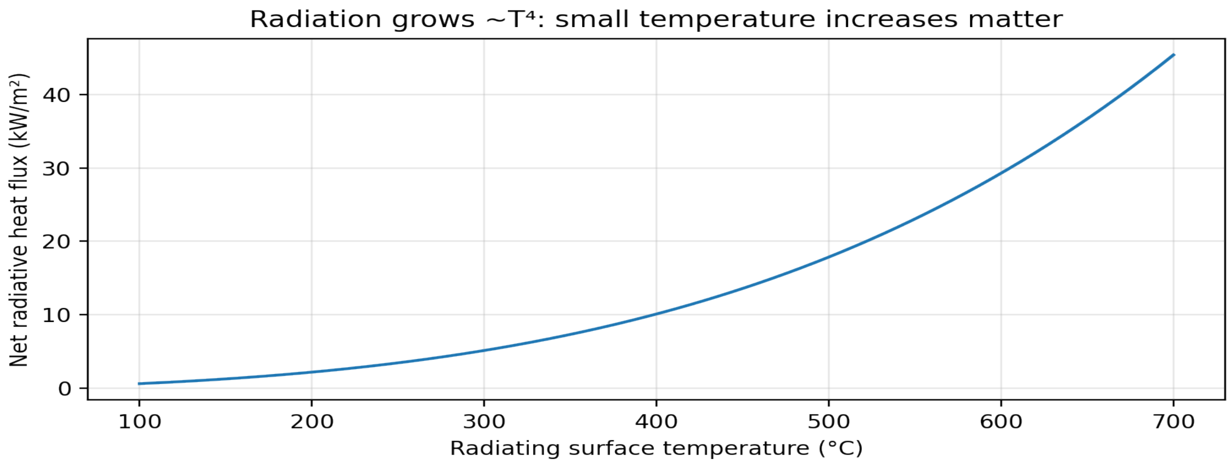
Worked example (50,000 BTU/h natural gas burner)

Input power is **14.65 kW**. Define an application-level efficiency η_{people} as the fraction of input power that lands on occupants as useful radiation (direct flame IR + hot-surface IR).

Scenario	η_people	Heat to people	Burner for same warmth
Open fire pit (baseline)	20%	2.93 kW	50,000 BTU/h
With radiant canopy (target)	45%	6.59 kW	22,222 BTU/h

One plausible canopy-only radiation estimate

If the underside of the canopy runs around **450°C** (723 K) with effective emissivity ε≈0.85, its net radiative flux is about **12.8 kW/m²**. With radiating area A≈0.8 m² and view factor to people F≈0.35, the canopy alone can deliver roughly **3.6 kW** to occupants (before adding direct flame radiation).



Engineering the canopy: what to optimize

Geometry: shallow dome spreads heat; deeper dome concentrates it. Add a flared rim (or faceted petals) to push radiation outward to a seating ring. **Two-zone underside:** (A) central *reflective* zone to redirect flame IR, (B) perimeter *high-emissivity* ring heated by exhaust. **Thermal path:** encourage hot products of combustion to sweep the underside (guided flow channels) before exiting. **Materials/coatings:** polished stainless/aluminized steel for IR reflection; black ceramic/enamel for durable emitting zones; insulate the top side to keep heat where it helps.

Practical constraints: maintain combustion air, provide a safe exhaust gap, keep surfaces and linkages guarded, and design for wind (flame stability, tip resistance, and clearance to combustibles).