Power Budget Analysis for Raspberry Pi 4B Host Nodes over PoE/PoE+

Date: 10 July 2025

1 Introduction

This report provides an updated power-budget calculation for four deployment scenarios involving headless Raspberry Pi 4B Host Nodes fitted with the official PoE or PoE+ HATs. Each node runs Raspberry Pi OS 64-bit Lite and hosts OctoPrint and MJPG-streamer services. Web-cams stream at 720 p, 10 fps. No on-board AI processing is planned.

2 Key Assumptions

Item	Design-centre Value
Pi 4 B (heavy load, fan on)	≈ 7 W at 5 V
Web-cam (720 p @ 10 fps)	2.5 W (0.5 A @ 5 V)
PoE+ HAT efficiency	85 %
PoE-af HAT efficiency	90 %
PoE delivery limits	25.5 W (802.3at), 12.95 W (802.3af)

3 Scenario Breakdown

Scenario 1 – 11 Nodes, 2 Cams per Node, PoE+

Parameter	Value
Number of Host Nodes	11
Web-cams per Node	2
PoE Standard	IEEE 802.3at (Type 2, PoE+)
PoE-HAT Efficiency (η)	85 %
Node Load (5 V rail)	12 W

Port Draw (incl. PoE losses)	14.1 W
Total Switch Budget	≈ 155 W
Recommended Switch	≥ 170 W, 16-port PoE+

Scenario 2 – 11 Nodes, 2 Cams per Node, PoE-af

Parameter	Value
Number of Host Nodes	11
Web-cams per Node	2
PoE Standard	IEEE 802.3af (Type 1, PoE)
PoE-HAT Efficiency (η)	90 %
Node Load (5 V rail)	12 W
Port Draw (incl. PoE losses)	13.3 W
Total Switch Budget	≈ 147 W
Recommended Switch	≥ 160 W, 16-port PoE-af

Scenario 3 – 22 Nodes, 1 Cam per Node, PoE+

Parameter	Value
Number of Host Nodes	22
Web-cams per Node	1
PoE Standard	IEEE 802.3at (Type 2, PoE+)
PoE-HAT Efficiency (η)	85 %
Node Load (5 V rail)	9.5 W
Port Draw (incl. PoE losses)	11.2 W
Total Switch Budget	≈ 246 W
Recommended Switch	≥ 300 W, 24-port PoE+

Scenario 4 – 22 Nodes, 1 Cam per Node, PoE-af

Parameter	Value
Number of Host Nodes	22
Web-cams per Node	1
PoE Standard	IEEE 802.3af (Type 1, PoE)
PoE-HAT Efficiency (η)	90 %
Node Load (5 V rail)	9.5 W
Port Draw (incl. PoE losses)	10.6 W
Total Switch Budget	≈ 232 W
Recommended Switch	≥ 260 W, 24-port PoE-af

4 Recommendations

• Budget roughly 15 W per two-camera node and 11 W per single-camera node at the switch, then add at least 15 % head-room to accommodate boot surges and future peripherals.

• For Scenario 1 an off-the-shelf 16-port PoE+ switch rated ≥ 170 W is adequate; Scenarios 3 & 4 require a 24-port chassis with ≥ 260–300 W.

• Although all ports remain under the IEEE limits, choose switches whose usable PSE budget meets or exceeds the figures in Section 3, not just their theoretical maximum.

Scenario	Practical PSE choice
1 (11 dual-cam PoE+)	A 16-port **PoE+** switch rated ≥ 170 W gives ~10 % head-room.
2 (11 dual-cam PoE)	A 16-port **PoE-af** switch with a 160 W (or higher) budget works, but make sure advertised power is "usable", not "theoretical".
3 (22 single-cam PoE+)	A 24-port **PoE+** switch rated ≥ 300 W keeps load under 85 % and leaves room for one spare port.
4 (22 single-cam PoE)	A 24-port **PoE-af** switch rated for ≥ 260 W (many enterprise af switches are 250 - 370 W) will suffice.

5 Assumptions

Item	Value used	Why this figure?
Raspberry Pi 4 Model B, PoE(H)AT fan running, both CPUs & GPUs moderately loaded (multiple USB, two Python services)	**≈ 7 W @ 5 V**	Stress-test measurements report 7–7.6 W at the Pi's 5 V rail when all cores are busy and HDMI is off (Raspberry Pi Forums, Core Electronics)
UVC webcam streaming 720 p @ 10 fps	**2.5 W (0.5 A @ 5 V)**	Vendor data sheets for HD webcams list 5 V × 0.5 A typical; that is 2.5 W (EMEET, Cable Society)
PoE HAT conversion efficiency	85 % (PoE+) / 90 % (PoE-af)	As before; the newer PoE+ HAT runs a little less efficient than the original model
PoE power limits	12.95 W to PD (af / Type 1), 25.5 W to PD (at / Type 2)	IEEE 802.3af / 802.3at tables (Wikipedia, Biamp Cornerstone)

6 Load Model

Dual-camera node: 7 W + 2 × 2.5 W = 12 W @ 5 V

Single-camera node: 7 W + 1 × 2.5 W = 9.5 W @ 5 V

Power draw at switch port = node load ÷ efficiency

7 Scenarios Summarized

Scenario	Nodes	Web-cams / node	PoE flavour	η (efficiency)	Node load (5 V)	Port draw (W)	Total switch budget
1	11	2	PoE + (802.3at)	0.85	12 W	**14.1 W**	**≈ 155 W**
2	11	2	PoE (802.3af)	0.90	12 W	**13.3 W**	**≈ 147 W**
3	22	1	PoE + (802.3at)	0.85	9.5 W	**11.2 W**	**≈ 246 W**
4	22	1	PoE (802.3af)	0.90	9.5 W	**10.6 W**	**≈ 232 W**

8 Key Considerations

- For Scenario 2 and 4, our 12W is operating at ~93% of the 12.95 W PoE delivery limit
- Long-term stability - running near maximum sustained draw increases the likelihood of instability if workloads change or USB power draw fluctuates.
- For peace of mind and future flexibility, use PoE+ (802.3at) for these nodes. The 12 W load is easily handled by PoE+, and you gain operational margin with minimal extra cost per port.