Online Resource 1. Extended methods and results

Supplementary material to: Fanless photovoltaic–thermal night heat rejection and greywater-fed hybrid cooling for host-sited AI computing: sub-model validation, uncertainty and a Los Angeles case study. Submitted to *Sustainable Energy Technologies and Assessments*.

Jonathan Karl Bily, Cloud Wash Laundry Corporation, Zaragoza, Spain (jonathan@cloudwashlaundry.com)

All values in this document were regenerated on 18 November 2026 from the code and weather files of Online Resource 3 for the configuration of the main text: 45 °C supply and 60 °C return, a 24-hour laundromat with dryer heat recovery and off-peak pricing, nine climates, and the coupled (ε–NTU, 45 °C outlet) coil model. Case A is the 58 kW module with 100 PVT panels and a 30 kW coil; Case B the 130.5 kW module with 200 panels and a 40 kW coil. Unless stated otherwise the values are for the central inputs of Table 1 of the main text.

S1 Methods supplement

S1.1 Climates

Table S1. Climate summary from the weather files (TMY3 for the US sites, CWEC 2020 for the Canadian sites).

Site	Zone	Mean T (°C)	99th pct T (°C)	99th pct T_{wb} (°C)	Mean night T (°C)	Hours ≥ 35 °C	Mean cloud
Phoenix	2B hot-dry	23.8	42.2	24.3	20.3	1,364	0.23
Las Vegas	3B warm-dry	19.8	40.6	22.0	15.9	859	0.22
Fresno	3B warm-dry (Mediterranean)	17.9	38.3	21.5	14.3	415	0.28
Los Angeles	3B warm-dry (coastal)	16.8	25.0	19.5	15.2	0	0.41
San Francisco	3C marine	13.8	25.0	17.4	11.8	0	0.37
Miami	1A hot-humid	24.5	32.2	25.8	22.8	6	0.47
Chicago	5A cold-humid	10.0	31.1	24.8	6.5	1	0.53
Vancouver	4C marine	10.6	22.8	18.3	8.4	0	0.65
Winnipeg	7 very cold	3.9	28.6	23.1	-0.5	0	0.58

S1.2 Coupled coil model

Section 2.5 of the main text gives the ε–NTU formulation. Table S2 compares the capacity of the 30 kW coil with the water leaving at 45 °C against the earlier fixed-conductance form, and Table S3 gives the annual effect of the coil specification at the four warmest sites in Case B (anchored pad and fan values). Case A had zero pad hours, zero water and zero unmet heat for every specification at these sites.

Table S2. Capacity (kW) of the 30 kW-rated coil with 60 °C entering and 45 °C leaving water, full fan speed.

Entering air (°C)	20	25	30	35	38	40	42	44
Coupled ε–NTU	131.4	110.9	90.0	69.0	56.5	47.6	37.8	25.4
Fixed conductance (earlier)	120.0	105.0	90.0	75.0	66.0	60.0	54.0	48.0

Entering air (°C)	20	25	30	35	38	40	42	44
Coupled, pads at 0.75, T_{wb} 22 °C	131.4	120.2	115.0	109.9	106.8	104.7	102.6	100.5

Table S3. Coil specification sensitivity, Case B, anchored pad and fan values: pad hours / cooling water (m^3 yr^{-1}) / unmet heat (MWh yr^{-1}).

Coil specification	Phoenix	Las Vegas	Miami	Los Angeles
Central (5 K / 6 K / 0.6)	30 / 1.8 / 0.00	14 / 0.7 / 0.00	0 / 0.0 / 0.00	0 / 0.0 / 0.00
Fixed conductance (earlier)	0 / 0.2 / 0.00	0 / 0.2 / 0.00	0 / 0.0 / 0.00	0 / 0.0 / 0.00
Fluid range 3 K	85 / 2.8 / 0.00	18 / 0.9 / 0.00	0 / 0.0 / 0.00	0 / 0.0 / 0.00
Fluid range 7 K	7 / 0.8 / 0.00	4 / 0.4 / 0.00	0 / 0.0 / 0.00	0 / 0.0 / 0.00
Air rise 5 K	32 / 1.9 / 0.00	15 / 0.7 / 0.00	0 / 0.0 / 0.00	0 / 0.0 / 0.00
Air rise 8 K	30 / 1.7 / 0.00	13 / 0.6 / 0.00	0 / 0.0 / 0.00	0 / 0.0 / 0.00
Part-speed exponent 0.5	30 / 1.8 / 0.00	14 / 0.7 / 0.00	0 / 0.0 / 0.00	0 / 0.0 / 0.00
Part-speed exponent 0.8	30 / 1.8 / 0.00	14 / 0.7 / 0.00	0 / 0.0 / 0.00	0 / 0.0 / 0.00

S1.3 PVT along-flow coupling

Table S4 gives, for each site, the ratio of the area-mean night flux when the fluid is cooled from 60 to 45 °C along the absorber, with fluid-to-surface conductance U_{fs}, to the flux at the uniform 47.5 °C surface used in the model (median over every 25th night hour).

Table S4. Coupled-to-lumped PVT flux ratio by fluid-to-surface conductance (W m^{-2} K^{-1}).

Site	Bare, 50	Bare, 100	Bare, 200	Bare, ∞	Full, 50	Full, 100	Full, 200
Phoenix	0.96	1.05	1.10	1.15	0.87	0.98	1.06
Las Vegas	0.93	1.02	1.07	1.13	0.82	0.94	1.03
Fresno	0.95	1.03	1.08	1.14	0.85	0.97	1.04
Los Angeles	0.96	1.04	1.09	1.15	0.86	0.98	1.05
San Francisco	0.93	1.02	1.07	1.13	0.81	0.95	1.02
Miami	0.98	1.07	1.12	1.18	0.87	0.99	1.07
Chicago	0.92	1.01	1.06	1.12	0.81	0.94	1.02
Vancouver	0.93	1.02	1.07	1.13	0.84	0.96	1.03
Winnipeg	0.90	0.99	1.04	1.11	0.77	0.91	1.00

S2 Results supplement

S2.1 Where the heat goes

Table S5. Annual heat allocation, Case A (MWh yr^{-1}): heat used by the host, PVT passive and film rejection, dry and adiabatic coil rejection, unmet heat, and fan hours.

Site	Host	PVT passive	PVT film	Coil dry	Coil adiabatic	Unmet	Fan h (night)
Phoenix	320.9	12.6	0.0	12.1	0.0	0.00	1,111 (0)

Site	Host	PVT passive	PVT film	Coil dry	Coil adiabatic	Unmet	Fan h (night)
Las Vegas	320.9	8.4	0.0	16.3	0.0	0.00	1,351 (0)
Fresno	320.9	10.7	0.0	14.0	0.0	0.00	1,221 (0)
Los Angeles	320.9	10.0	0.0	14.7	0.0	0.00	1,278 (0)
San Francisco	320.9	11.5	0.0	13.1	0.0	0.00	1,171 (0)
Miami	320.9	12.0	0.0	12.7	0.0	0.00	1,162 (0)
Chicago	320.9	9.2	0.0	15.5	0.0	0.00	1,290 (0)
Vancouver	320.9	13.8	0.0	10.8	0.0	0.00	995 (0)
Winnipeg	320.9	14.8	0.0	9.8	0.0	0.00	941 (0)

Table S6. Annual heat allocation, Case B (MWh yr^{-1}): heat used by the host, PVT passive and film rejection, dry and adiabatic coil rejection, unmet heat, and fan hours.

Site	Host	PVT passive	PVT film	Coil dry	Coil adiabatic	Unmet	Fan h (night)
Phoenix	350.3	234.3	0.1	192.5	0.2	0.00	4,525 (0)
Las Vegas	350.3	222.6	0.0	204.4	0.1	0.00	4,555 (0)
Fresno	350.3	234.0	0.0	193.0	0.0	0.00	4,390 (0)
Los Angeles	350.3	229.2	0.0	197.9	0.0	0.00	4,472 (0)
San Francisco	350.3	235.6	0.0	191.4	0.0	0.00	4,404 (0)
Miami	350.3	232.5	0.0	194.5	0.0	0.00	4,530 (0)
Chicago	350.3	224.7	0.0	202.3	0.0	0.00	4,547 (0)
Vancouver	350.3	247.4	0.0	179.7	0.0	0.00	4,225 (0)
Winnipeg	350.3	248.9	0.0	178.2	0.0	0.00	4,250 (0)

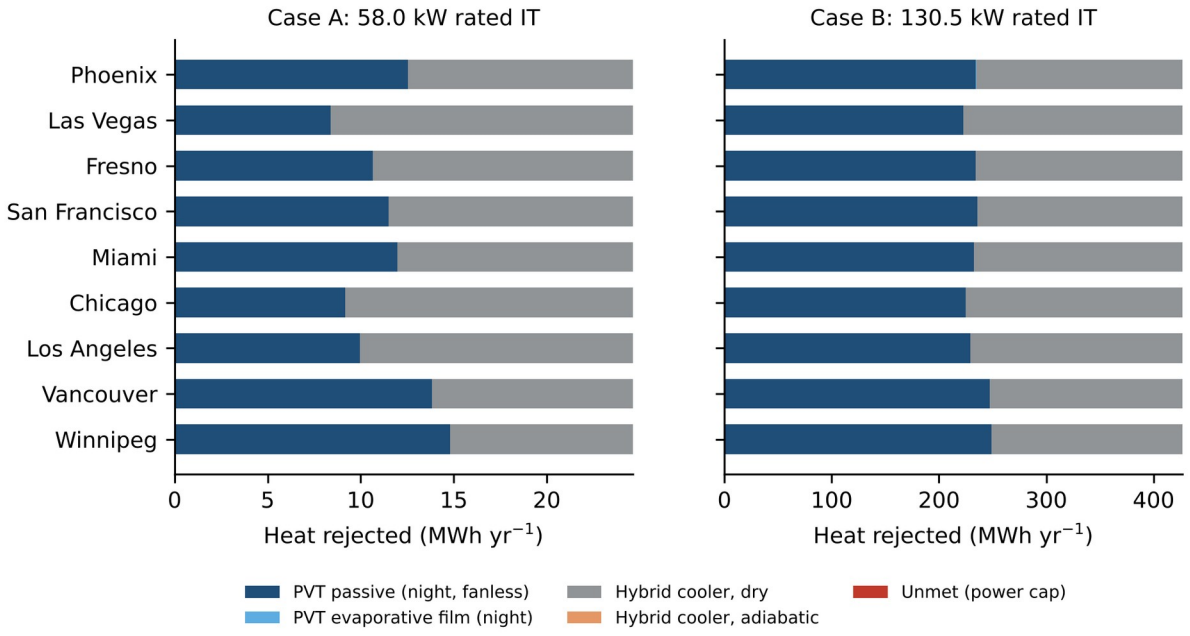

Fig. S1. Annual heat rejected by each stage of the rejection plant for the two module sizes.

S2.2 Water use

Table S7. Annual cooling water by end use, Case A (m^3 yr^{-1}), with the RO permeate produced and the share of total water from recycled greywater.

Site	Total	Municipal	PVT film	Pads	Flush	Permeate	WUE (L kWh^{-1})
Phoenix	0.0	0.0	0.0	0.0	0.0	1.0	0.00
Las Vegas	0.0	0.0	0.0	0.0	0.0	1.0	0.00
Fresno	0.0	0.0	0.0	0.0	0.0	1.0	0.00
Los Angeles	0.0	0.0	0.0	0.0	0.0	1.0	0.00
San Francisco	0.0	0.0	0.0	0.0	0.0	1.0	0.00
Miami	0.0	0.0	0.0	0.0	0.0	1.0	0.00
Chicago	0.0	0.0	0.0	0.0	0.0	1.0	0.00
Vancouver	0.0	0.0	0.0	0.0	0.0	1.0	0.00
Winnipeg	0.0	0.0	0.0	0.0	0.0	1.0	0.00

Table S8. Annual cooling water by end use, Case B (m^3 yr^{-1}), with the RO permeate produced and the share of total water from recycled greywater.

Site	Total	Municipal	PVT film	Pads	Flush	Permeate	WUE (L kWh^{-1})
Phoenix	1.8	0.0	0.1	0.2	1.4	2.8	0.00
Las Vegas	0.5	0.0	0.0	0.1	0.4	1.5	0.00
Fresno	0.0	0.0	0.0	0.0	0.0	1.0	0.00
Los Angeles	0.0	0.0	0.0	0.0	0.0	1.0	0.00
San Francisco	0.0	0.0	0.0	0.0	0.0	1.0	0.00
Miami	0.0	0.0	0.0	0.0	0.0	1.0	0.00
Chicago	0.0	0.0	0.0	0.0	0.0	1.0	0.00
Vancouver	0.0	0.0	0.0	0.0	0.0	1.0	0.00
Winnipeg	0.0	0.0	0.0	0.0	0.0	1.0	0.00

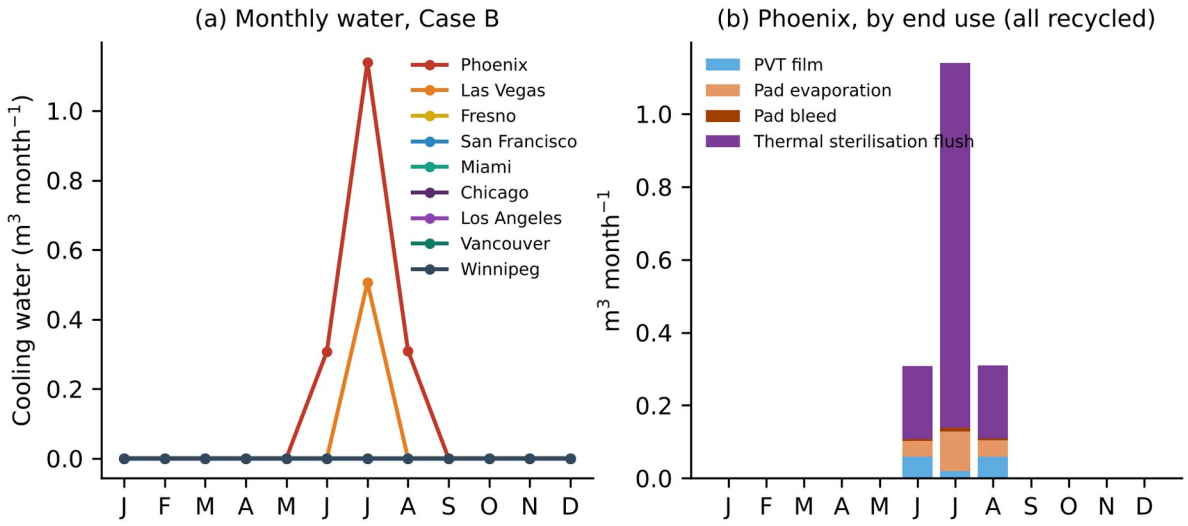

Fig. S2. Monthly cooling water, Case B, for each climate (a), and for Phoenix by end use (b).

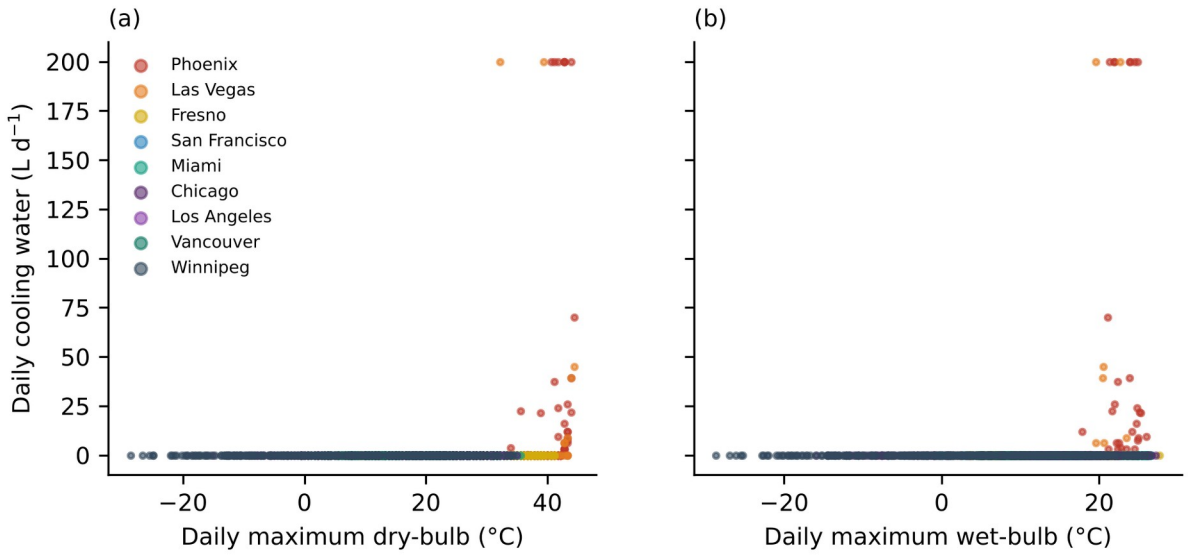

Fig. S3. Daily cooling water, Case B, against daily maximum dry-bulb (a) and wet-bulb (b) temperature.

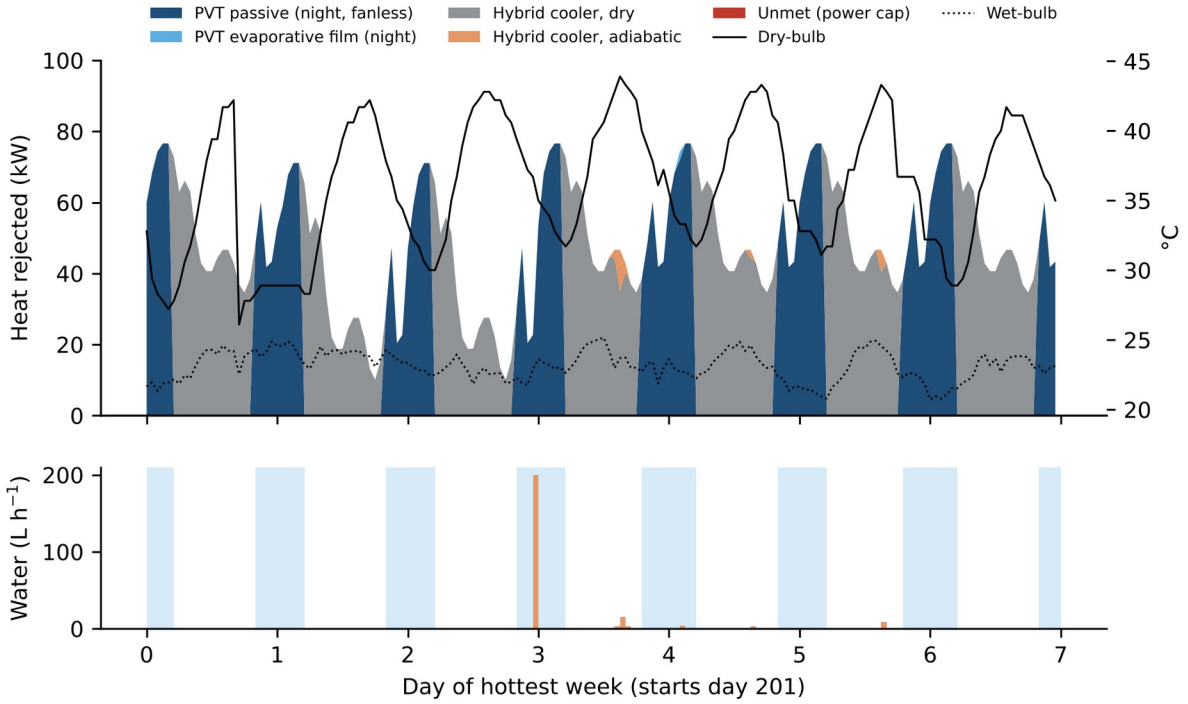

Fig. S4. Hourly dispatch during the hottest week of the Phoenix year, Case B.

S2.3 Comparison with an evaporative tower

Table S9. Comparison with an open evaporative tower, Case A. Equal duty: the tower rejects the same residual heat; whole module: the tower rejects all captured heat.

Site	Tower water, equal duty (m^3)	Tower water, whole module (m^3)	Proposed water (m^3)	Water reduction, equal duty (%)	Rejection electricity, proposed / tower (MWh)	Electricity reduction (%)	Tower latent fraction
Phoenix	44	651	0.0	100	0.21 / 0.49	58	0.85
Las Vegas	43	631	0.0	100	0.21 / 0.49	58	0.82

Site	Tower water, equal duty (m^3)	Tower water, whole module (m^3)	Proposed water (m^3)	Water reduction, equal duty (%)	Rejection electricity, proposed / tower (MWh)	Electricity reduction (%)	Tower latent fraction
Fresno	42	611	0.0	100	0.21 / 0.49	58	0.80
Los Angeles	42	599	0.0	100	0.21 / 0.49	58	0.78
San Francisco	41	584	0.0	100	0.21 / 0.49	58	0.76
Miami	44	632	0.0	100	0.21 / 0.49	58	0.82
Chicago	39	561	0.0	100	0.21 / 0.49	58	0.73
Vancouver	40	566	0.0	100	0.21 / 0.49	58	0.74
Winnipeg	37	526	0.0	100	0.21 / 0.49	58	0.69

Table S10. Comparison with an open evaporative tower, Case B. Equal duty: the tower rejects the same residual heat; whole module: the tower rejects all captured heat.

Site	Tower water, equal duty (m^3)	Tower water, whole module (m^3)	Proposed water (m^3)	Water reduction, equal duty (%)	Rejection electricity, proposed / tower (MWh)	Electricity reduction (%)	Tower latent fraction
Phoenix	796	1,464	1.8	100	3.79 / 8.54	56	0.85
Las Vegas	773	1,421	0.5	100	3.66 / 8.54	57	0.82
Fresno	746	1,374	0.0	100	3.54 / 8.54	59	0.80
Los Angeles	737	1,347	0.0	100	3.48 / 8.54	59	0.78
San Francisco	718	1,314	0.0	100	3.47 / 8.54	59	0.76
Miami	778	1,423	0.0	100	3.54 / 8.54	59	0.82
Chicago	690	1,263	0.0	100	3.49 / 8.54	59	0.73
Vancouver	697	1,273	0.0	100	3.47 / 8.54	59	0.74
Winnipeg	646	1,184	0.0	100	3.47 / 8.54	59	0.69

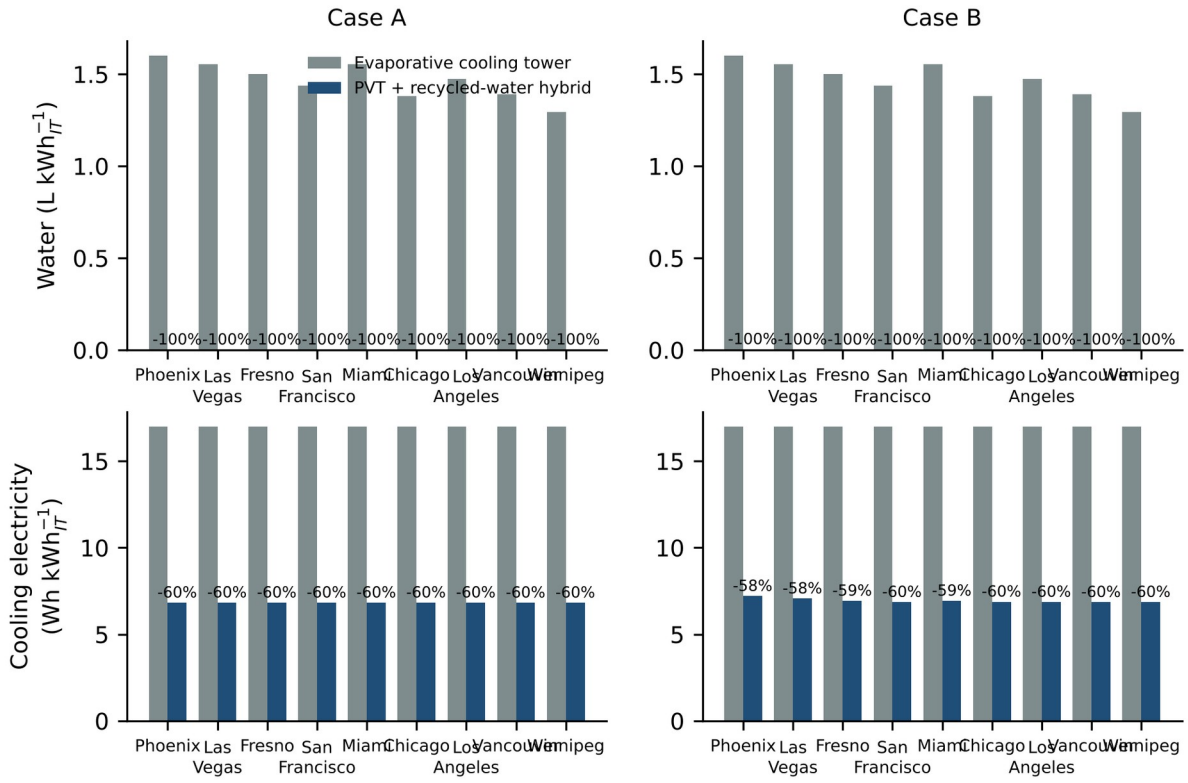

Fig. S5. Water usage effectiveness (top) and cooling electricity per kWh of IT electricity (bottom), proposed system and evaporative tower.

S2.4 Comparison with a dry cooler

Table S11. Dry cooler sized to the same residual with the same coil specification and 45 °C outlet, Case A: design sizing (0.4% dry bulb) and reliability sizing (every hour).

Site	Proposed rejection electricity (MWh)	Dry, design: rating (kW) / electricity (MWh)	Dry, design: night fan h / unmet (MWh)	Dry, reliability: rating (kW) / electricity (MWh)	Dry, design, 0.053 fan coefficient (MWh)
Phoenix	0.21	25 / 0.21	820 / 0.00	11 / 0.23	0.22
Las Vegas	0.21	22 / 0.21	580 / 0.00	9 / 0.23	0.22
Fresno	0.21	16 / 0.21	710 / 0.00	7 / 0.24	0.21
Los Angeles	0.21	8 / 0.23	653 / 0.00	6 / 0.25	0.25
San Francisco	0.21	8 / 0.22	760 / 0.00	6 / 0.24	0.23
Miami	0.21	11 / 0.23	769 / 0.00	8 / 0.25	0.25
Chicago	0.21	10 / 0.21	641 / 0.00	7 / 0.22	0.22
Vancouver	0.21	7 / 0.22	936 / 0.00	6 / 0.23	0.24
Winnipeg	0.21	9 / 0.21	990 / 0.00	7 / 0.22	0.22

Table S12. Dry cooler sized to the same residual with the same coil specification and 45 °C outlet, Case B: design sizing (0.4% dry bulb) and reliability sizing (every hour).

Site	Proposed rejection electricity (MWh)	Dry, design: rating (kW) / electricity (MWh)	Dry, design: night fan h / unmet (MWh)	Dry, reliability: rating (kW) / electricity (MWh)	Dry, design, 0.053 fan coefficient (MWh)
Phoenix	3.79	69 / 3.63	4,235 / 0.00	64 / 3.65	3.80
Las Vegas	3.66	63 / 3.60	4,205 / 0.00	64 / 3.60	3.74
Fresno	3.54	44 / 3.59	4,370 / 0.00	33 / 3.72	3.73
Los Angeles	3.48	22 / 3.96	4,288 / 0.00	18 / 4.31	4.38
San Francisco	3.47	23 / 3.78	4,356 / 0.00	17 / 4.22	4.06
Miami	3.54	30 / 3.99	4,230 / 0.00	24 / 4.44	4.43
Chicago	3.49	29 / 3.66	4,213 / 0.00	22 / 3.87	3.85
Vancouver	3.47	20 / 3.86	4,535 / 0.00	17 / 4.10	4.20
Winnipeg	3.47	26 / 3.62	4,510 / 0.00	19 / 3.82	3.78

S2.5 Host type

Table S13. Host type, Case A, four representative sites: heat used by the host, fuel displaced, cooling water, rejection electricity of the proposed system and of the dry cooler, and night fan hours.

Host, site	Heat used (MWh)	Fuel displaced (MWh)	Water (m^3)	Rejection electricity (MWh)	Dry cooler electricity (MWh)	Night fan h
Laundromat, Phoenix	321	388	0.0	0.21	0.21	0
Laundromat, Los Angeles	321	383	0.0	0.21	0.23	0
Laundromat, Chicago	321	383	0.0	0.21	0.21	0
Laundromat, Winnipeg	321	385	0.0	0.21	0.21	0
Car wash, Phoenix	208	245	0.2	1.13	1.18	0
Car wash, Los Angeles	208	245	0.0	1.12	1.25	0
Car wash, Chicago	208	245	0.0	1.12	1.17	0
Car wash, Winnipeg	208	245	0.0	1.12	1.16	0
Commercial laundry, Phoenix	232	360	1.3	1.02	1.00	0
Commercial laundry, Los Angeles	232	330	0.0	0.92	1.20	0
Commercial laundry, Chicago	232	334	0.0	0.92	1.03	0
Commercial laundry, Winnipeg	232	346	0.0	0.92	1.01	0

Table S14. Host type, Case B, four representative sites: heat used by the host, fuel displaced, cooling water, rejection electricity of the proposed system and of the dry cooler, and night fan hours.

Host, site	Heat used (MWh)	Fuel displaced (MWh)	Water (m^3)	Rejection electricity (MWh)	Dry cooler electricity (MWh)	Night fan h
Laundromat, Phoenix	350	412	1.8	3.79	3.63	0
Laundromat, Los Angeles	350	412	0.0	3.48	3.96	0
Laundromat, Chicago	350	412	0.0	3.49	3.66	0
Laundromat, Winnipeg	350	412	0.0	3.47	3.62	0
Car wash, Phoenix	208	245	5.3	5.35	4.88	0
Car wash, Los Angeles	208	245	0.0	4.65	5.39	0
Car wash, Chicago	208	245	0.0	4.67	4.92	0
Car wash, Winnipeg	208	245	0.0	4.63	4.86	0
Commercial laundry, Phoenix	479	737	11.3	2.85	2.62	0
Commercial laundry, Los Angeles	479	678	0.0	2.46	3.14	0
Commercial laundry, Chicago	479	686	0.0	2.46	2.69	0
Commercial laundry, Winnipeg	479	709	0.0	2.44	2.65	0

S2.6 What each element contributes

Table S15. Contribution of each element, Case A: total / municipal water (m^3 yr^{-1}) and night fan hours.

Site	Proposed	Without recycling	Without PVT (recycled)	Without PVT or recycling	Dry only, no PVT: unmet (MWh)	Fans before film at night	Store shifted into night
Phoenix	0.0 / 0.0 (0 h)	0.0 / 0.0	0.0 (820 h)	0.0 / 0.0	0.00	0.0 (0 h)	0.0
Las Vegas	0.0 / 0.0 (0 h)	0.0 / 0.0	0.0 (580 h)	0.0 / 0.0	0.00	0.0 (0 h)	0.0
Fresno	0.0 / 0.0 (0 h)	0.0 / 0.0	0.0 (710 h)	0.0 / 0.0	0.00	0.0 (0 h)	0.0
Los Angeles	0.0 / 0.0 (0 h)	0.0 / 0.0	0.0 (653 h)	0.0 / 0.0	0.00	0.0 (0 h)	0.0
San Francisco	0.0 / 0.0 (0 h)	0.0 / 0.0	0.0 (760 h)	0.0 / 0.0	0.00	0.0 (0 h)	0.0
Miami	0.0 / 0.0 (0 h)	0.0 / 0.0	0.0 (769 h)	0.0 / 0.0	0.00	0.0 (0 h)	0.0
Chicago	0.0 / 0.0 (0 h)	0.0 / 0.0	0.0 (641 h)	0.0 / 0.0	0.00	0.0 (0 h)	0.0
Vancouver	0.0 / 0.0 (0 h)	0.0 / 0.0	0.0 (936 h)	0.0 / 0.0	0.00	0.0 (0 h)	0.0
Winnipeg	0.0 / 0.0 (0 h)	0.0 / 0.0	0.0 (990 h)	0.0 / 0.0	0.00	0.0 (0 h)	0.0

Table S16. Contribution of each element, Case B: total / municipal water (m^3 yr^{-1}) and night fan hours.

Site	Proposed	Without recycling	Without PVT (recycled)	Without PVT or recycling	Dry only, no PVT: unmet (MWh)	Fans before film at night	Store shifted into night
Phoenix	1.8 / 0.0 (0 h)	1.8 / 1.8	1.6 (4,235 h)	1.7 / 1.7	0.17	1.6 (16 h)	1.7

Site	Proposed	Without recycling	Without PVT (recycled)	Without PVT or recycling	Dry only, no PVT: unmet (MWh)	Fans before film at night	Store shifted into night
Las Vegas	0.5 / 0.0 (0 h)	0.5 / 0.5	0.5 (4,205 h)	0.5 / 0.5	0.08	0.5 (0 h)	0.5
Fresno	0.0 / 0.0 (0 h)	0.0 / 0.0	0.0 (4,370 h)	0.0 / 0.0	0.00	0.0 (0 h)	0.0
Los Angeles	0.0 / 0.0 (0 h)	0.0 / 0.0	0.0 (4,288 h)	0.0 / 0.0	0.00	0.0 (0 h)	0.0
San Francisco	0.0 / 0.0 (0 h)	0.0 / 0.0	0.0 (4,356 h)	0.0 / 0.0	0.00	0.0 (0 h)	0.0
Miami	0.0 / 0.0 (0 h)	0.0 / 0.0	0.0 (4,230 h)	0.0 / 0.0	0.00	0.0 (0 h)	0.0
Chicago	0.0 / 0.0 (0 h)	0.0 / 0.0	0.0 (4,213 h)	0.0 / 0.0	0.00	0.0 (0 h)	0.0
Vancouver	0.0 / 0.0 (0 h)	0.0 / 0.0	0.0 (4,535 h)	0.0 / 0.0	0.00	0.0 (0 h)	0.0
Winnipeg	0.0 / 0.0 (0 h)	0.0 / 0.0	0.0 (4,510 h)	0.0 / 0.0	0.00	0.0 (0 h)	0.0

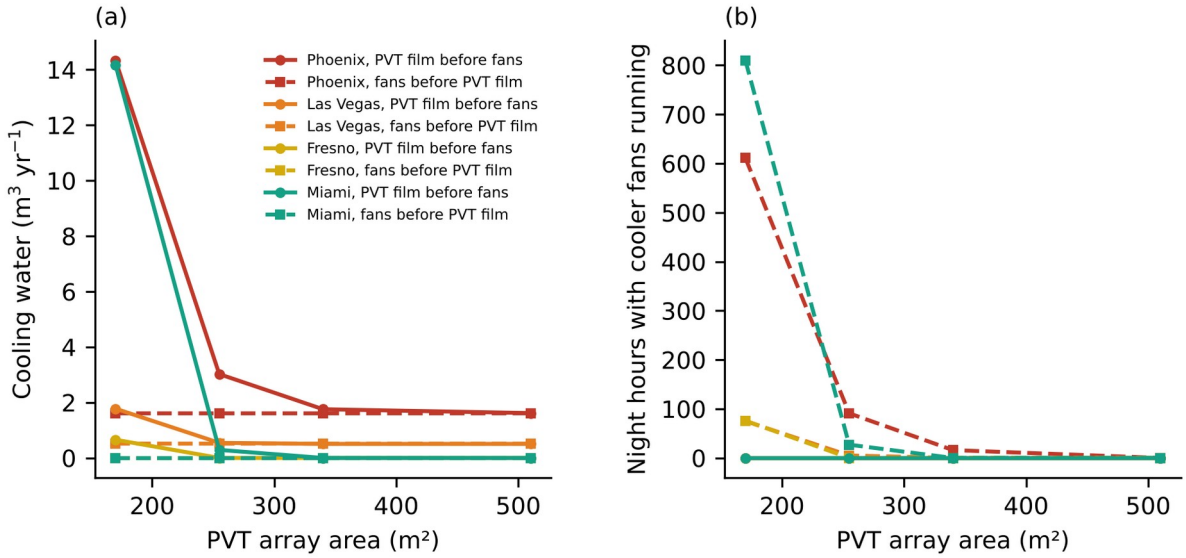

Fig. S6. Effect of PVT array area, Case B, on (a) annual cooling water and (b) night hours with cooler fans.

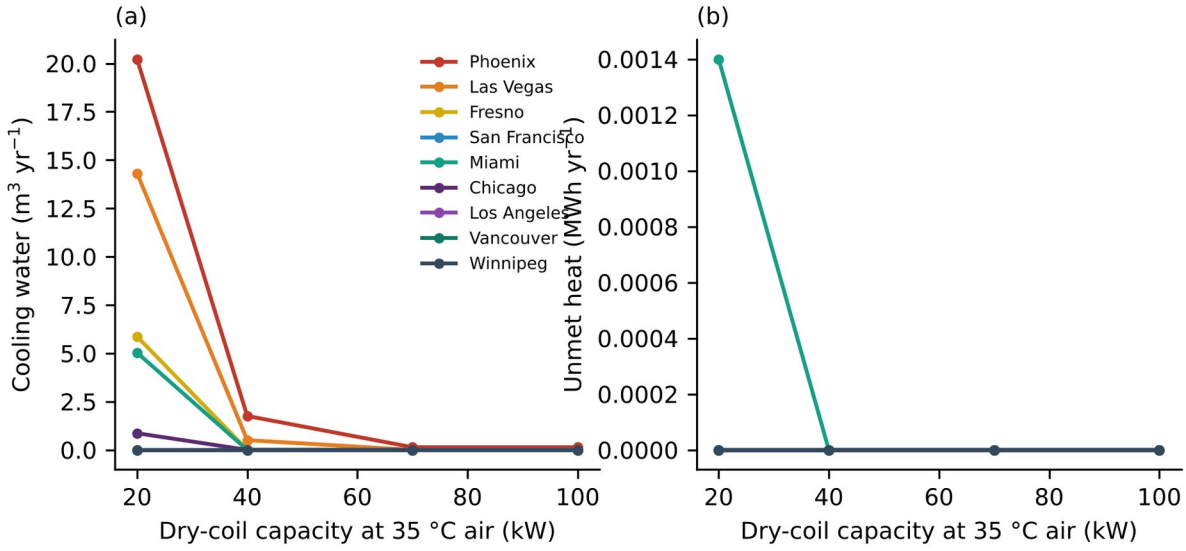

Fig. S7. Effect of coil rating, Case B, on (a) annual cooling water and (b) unmet heat.

S2.7 One-at-a-time sensitivity

Table S17. One-at-a-time sensitivity, Case A: range over the nine sites of annual cooling water, night fan hours and the largest unmet heat.

Input	Water (m^3 yr^{-1})	Night fan h	Max unmet (MWh)
Coil rating (kW) = 10.0	0.0–0.0	0–0	0.00
Coil rating (kW) = 20.0	0.0–0.0	0–0	0.00
Coil rating (kW) = 30.0	0.0–0.0	0–0	0.00
Coil rating (kW) = 45.0	0.0–0.0	0–0	0.00
IT utilisation = 0.6	0.0–0.0	0–0	0.00
IT utilisation = 0.8	0.0–0.0	0–0	0.00
IT utilisation = 0.95	0.0–0.0	0–0	0.00
Wash-water heat share = 0.25	0.0–0.0	0–0	0.00
Wash-water heat share = 0.6	0.0–0.0	0–0	0.00
Wash-water heat share = 1.0	0.0–0.0	0–0	0.00
PVT surface temperature (°C) = 42.5	0.0–0.0	0–0	0.00
PVT surface temperature (°C) = 47.5	0.0–0.0	0–0	0.00
PVT surface temperature (°C) = 52.5	0.0–0.0	0–0	0.00
Return temperature (°C) = 55.0	0.0–0.0	0–0	0.00
Return temperature (°C) = 60.0	0.0–0.0	0–0	0.00
Return temperature (°C) = 65.0	0.0–0.0	0–0	0.00
PVT panels = 50	0.0–0.1	0–0	0.00
PVT panels = 100	0.0–0.0	0–0	0.00
PVT panels = 150	0.0–0.0	0–0	0.00
Host = laundromat	0.0–0.0	0–0	0.00
Host = carwash	0.0–0.2	0–0	0.00
PVT capacity multiplier = 0.74	0.0–0.0	0–0	0.00
PVT capacity multiplier = 1.0	0.0–0.0	0–0	0.00

Table S18. One-at-a-time sensitivity, Case B: range over the nine sites of annual cooling water, night fan hours and the largest unmet heat.

Input	Water (m^3 yr^{-1})	Night fan h	Max unmet (MWh)
PVT panels = 100	0.3–14.3	0–0	0.00
PVT panels = 150	0.0–3.0	0–0	0.00
PVT panels = 200	0.0–1.8	0–0	0.00
PVT panels = 300	0.0–1.6	0–0	0.00
Coil rating (kW) = 20.0	0.0–20.2	0–0	0.00
Coil rating (kW) = 40.0	0.0–1.8	0–0	0.00
Coil rating (kW) = 70.0	0.0–0.1	0–0	0.00
Coil rating (kW) = 100.0	0.0–0.1	0–0	0.00
IT utilisation = 0.6	0.0–0.0	0–0	0.00
IT utilisation = 0.8	0.0–1.8	0–0	0.00
IT utilisation = 0.95	0.0–6.4	0–0	0.00

Input	Water (m^3 yr^{-1})	Night fan h	Max unmet (MWh)
Wash-water heat share = 0.25	0.0–8.1	0–0	0.00
Wash-water heat share = 0.6	0.0–3.0	0–0	0.00
Wash-water heat share = 1.0	0.0–1.2	0–0	0.00
PVT surface temperature (°C) = 42.5	0.0–3.7	0–0	0.00
PVT surface temperature (°C) = 47.5	0.0–1.8	0–0	0.00
PVT surface temperature (°C) = 52.5	0.0–1.6	0–0	0.00
Return temperature (°C) = 55.0	0.0–3.5	0–0	0.00
Return temperature (°C) = 60.0	0.0–1.8	0–0	0.00
Return temperature (°C) = 65.0	0.0–0.8	0–0	0.00
Host = laundromat	0.0–1.8	0–0	0.00
Host = carwash	0.0–5.3	0–0	0.00
Greywater per load (L) = 15.0	0.0–1.8	0–0	0.00
Greywater per load (L) = 30.0	0.0–1.8	0–0	0.00
Greywater per load (L) = 60.0	0.0–1.8	0–0	0.00
RO recovery = 0.5	0.0–1.8	0–0	0.00
RO recovery = 0.6	0.0–1.8	0–0	0.00
RO recovery = 0.75	0.0–1.8	0–0	0.00
Buffer tank (m^3) = 0.5	0.0–1.8	0–0	0.00
Buffer tank (m^3) = 2.0	0.0–1.8	0–0	0.00
Buffer tank (m^3) = 5.0	0.0–1.8	0–0	0.00
Pad effectiveness = 0.7	0.0–1.8	0–0	0.00
Pad effectiveness = 0.85	0.0–1.8	0–0	0.00
Pad effectiveness = 0.95	0.0–1.8	0–0	0.00
PVT capacity multiplier = 0.74	0.0–3.2	0–0	0.00
PVT capacity multiplier = 1.0	0.0–1.8	0–0	0.00

S2.8 PVT capacity uncertainty

Table S19. PVT capacity uncertainty, Case A (standard dispatch, no quiet-hours options): annual cooling water (m^3) / night fan hours.

PVT capacity	Phoenix	Las Vegas	Fresno	L. Angeles	S. Francisco	Miami	Chicago	Vancouver	Winnipeg
Full model	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0
Full × 0.74	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0
Full × 0.50	0.1 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0
No plenum stack	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0
No shrouds	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0
No emitter	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0
No thermosiphon	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0
Bare × 0.74 (anchored)	0.4 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.3 / 0	0.0 / 0	0.0 / 0	0.0 / 0
Bare × 0.50	2.0 / 0	0.4 / 0	0.6 / 0	1.3 / 0	0.2 / 0	3.4 / 0	0.2 / 0	0.2 / 0	0.2 / 0

Table S20. PVT capacity uncertainty, Case B (standard dispatch, no quiet-hours options): annual cooling water (m^3) / night fan hours.

PVT capacity	Phoenix	Las Vegas	Fresno	L. Angeles	S. Francisco	Miami	Chicago	Vancouver	Winnipeg
Full model	1.8 / 0	0.5 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0
Full × 0.74	3.2 / 0	0.6 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.3 / 0	0.0 / 0	0.0 / 0	0.0 / 0
Full × 0.50	14.3 / 0	1.8 / 0	0.7 / 0	4.4 / 0	0.3 / 0	14.2 / 0	1.0 / 0	0.3 / 0	0.5 / 0
No plenum stack	1.9 / 0	0.5 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.1 / 0	0.0 / 0	0.0 / 0	0.0 / 0
No shrouds	1.9 / 0	0.5 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0
No emitter	2.0 / 0	0.5 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.0 / 0
No thermosiphon	3.1 / 0	0.5 / 0	0.0 / 0	0.0 / 0	0.0 / 0	0.3 / 0	0.0 / 0	0.0 / 0	0.0 / 0
Bare × 0.74 (anchored)	35.0 / 0	6.0 / 0	4.1 / 0	12.6 / 0	1.4 / 0	43.8 / 0	3.6 / 0	1.4 / 0	1.6 / 0
Bare × 0.50	112.8 / 13	39.9 / 8	59.2 / 36	81.6 / 0	40.9 / 0	134.3 / 58	31.2 / 57	35.1 / 107	19.9 / 37

S2.9 Break-even PVT capacity

Table S21. Minimum PVT capacity for zero fan operation 22:00–07:00, as a ratio to the validated bare-panel capacity, with the central and the measurement-anchored cooler (search not bounded at the 0.74 anchor).

Site	Case A, central cooler	Case A, anchored cooler	Case B, central cooler	Case B, anchored cooler
Phoenix	0.42	0.42	0.66	0.66
Las Vegas	0.50	0.50	0.76	0.76
Fresno	0.44	0.44	0.61	0.61
Los Angeles	0.38	0.38	0.58	0.58
San Francisco	0.31	0.31	0.49	0.49
Miami	0.41	0.41	0.58	0.58
Chicago	0.46	0.46	0.64	0.64
Vancouver	0.47	0.47	0.66	0.66
Winnipeg	0.43	0.43	0.60	0.60

S2.10 Store reserve: what it costs

The store reserve (Section 2.1 of the main text) holds the thermal store empty for the night by serving the host from the store first from 15:00 and declining routine surplus. Table S22 compares it with the standard dispatch at the anchored capacity for the 24-hour host and for a host that closes at 22:00, where it is needed. Removing the night fan hours costs heat delivered to the host (58 kW module) or extra daytime coil operation, electricity and noise (130.5 kW module).

Table S22. Store reserve against standard dispatch at the anchored capacity, for the 24-hour host and the host closing at 22:00: night fan hours, heat used by the host (MWh yr^{-1}), cooling electricity (MWh yr^{-1}), water (m^3 yr^{-1}) and day-time L_{Aeq} at 10 m (dB(A); – = no day-time fan operation).

Host, case, site	Standard: fan h / heat used / electricity / water / day L_{Aeq}	Reserve: fan h / heat used / electricity / water / day L_{Aeq}
24 h, A, Phoenix	0 / 320.9 / 2.78 / 0.5 / 11.8	0 / 294.5 / 2.77 / 1.4 / –
Closes 22:00, A, Phoenix	1 / 252.9 / 2.82 / 22.5 / 10.9	0 / 223.0 / 2.84 / 34.2 / –
24 h, B, Phoenix	0 / 350.3 / 6.90 / 41.9 / 40.0	0 / 350.3 / 7.60 / 55.5 / 46.2
Closes 22:00, B, Phoenix	1 / 304.6 / 6.86 / 121.3 / 36.6	0 / 304.3 / 7.53 / 134.9 / 45.2
24 h, A, Las Vegas	0 / 320.9 / 2.78 / 1.2 / 12.0	0 / 295.2 / 2.77 / 1.3 / –
Closes 22:00, A, Las Vegas	5 / 252.9 / 2.81 / 16.3 / 11.4	0 / 224.3 / 2.81 / 18.9 / –
24 h, B, Las Vegas	1 / 350.3 / 6.63 / 22.3 / 36.6	0 / 350.3 / 7.18 / 30.5 / 44.2
Closes 22:00, B, Las Vegas	9 / 304.6 / 6.62 / 62.7 / 34.2	0 / 304.3 / 7.12 / 70.9 / 43.5
24 h, A, Fresno	0 / 320.9 / 2.78 / 0.1 / 12.0	0 / 295.1 / 2.77 / 0.1 / –
Closes 22:00, A, Fresno	0 / 252.9 / 2.80 / 11.6 / 10.4	0 / 224.1 / 2.80 / 14.3 / –
24 h, B, Fresno	0 / 350.3 / 6.44 / 11.9 / 30.4	0 / 350.3 / 6.95 / 18.3 / 42.6
Closes 22:00, B, Fresno	2 / 304.6 / 6.50 / 59.9 / 27.6	0 / 304.3 / 6.97 / 66.2 / 42.2
24 h, A, San Francisco	0 / 320.9 / 2.78 / 0.0 / 11.9	0 / 294.9 / 2.77 / 0.0 / –
Closes 22:00, A, San Francisco	0 / 252.9 / 2.78 / 5.0 / 10.3	0 / 223.7 / 2.78 / 5.6 / –
24 h, B, San Francisco	0 / 350.3 / 6.31 / 3.2 / 21.3	0 / 350.3 / 6.37 / 3.5 / 27.8
Closes 22:00, B, San Francisco	0 / 304.6 / 6.37 / 29.9 / 21.8	0 / 304.3 / 6.42 / 30.1 / 27.6
24 h, A, Miami	0 / 320.9 / 2.78 / 0.3 / 12.0	0 / 295.2 / 2.77 / 1.0 / –
Closes 22:00, A, Miami	0 / 252.9 / 2.85 / 34.5 / 10.6	0 / 224.3 / 2.87 / 48.8 / -17.5
24 h, B, Miami	0 / 350.3 / 6.52 / 52.7 / 28.1	0 / 350.3 / 6.76 / 52.8 / 36.8
Closes 22:00, B, Miami	1 / 304.6 / 6.73 / 158.8 / 28.4	0 / 304.3 / 6.94 / 158.9 / 36.5
24 h, A, Chicago	0 / 320.9 / 2.78 / 0.2 / 12.0	0 / 295.2 / 2.77 / 0.2 / –
Closes 22:00, A, Chicago	0 / 252.9 / 2.80 / 10.7 / 10.5	0 / 224.3 / 2.79 / 12.7 / –
24 h, B, Chicago	0 / 350.3 / 6.35 / 11.8 / 23.9	0 / 350.3 / 6.45 / 11.8 / 32.5
Closes 22:00, B, Chicago	9 / 304.6 / 6.42 / 45.6 / 23.7	0 / 304.3 / 6.51 / 45.6 / 32.2
24 h, A, Los Angeles	0 / 320.9 / 2.78 / 0.1 / 12.0	0 / 295.2 / 2.77 / 0.1 / –
Closes 22:00, A, Los Angeles	0 / 252.9 / 2.82 / 19.5 / 10.5	0 / 224.3 / 2.82 / 24.6 / –
24 h, B, Los Angeles	0 / 350.3 / 6.36 / 21.7 / 22.3	0 / 350.3 / 6.43 / 21.7 / 28.8
Closes 22:00, B, Los Angeles	0 / 304.6 / 6.52 / 93.7 / 23.0	0 / 304.3 / 6.58 / 93.7 / 28.6
24 h, A, Vancouver	0 / 320.9 / 2.78 / 0.0 / 11.2	0 / 293.0 / 2.77 / 0.0 / –
Closes 22:00, A, Vancouver	0 / 252.9 / 2.78 / 5.1 / 9.2	0 / 221.0 / 2.78 / 6.2 / –
24 h, B, Vancouver	0 / 350.3 / 6.31 / 4.5 / 20.8	0 / 350.3 / 6.35 / 4.6 / 26.7
Closes 22:00, B, Vancouver	13 / 304.6 / 6.36 / 30.2 / 21.3	0 / 304.3 / 6.40 / 30.2 / 26.5
24 h, A, Winnipeg	0 / 320.9 / 2.78 / 0.0 / 11.1	0 / 292.7 / 2.77 / 0.0 / –
Closes 22:00, A, Winnipeg	0 / 252.9 / 2.78 / 4.4 / 9.0	0 / 220.6 / 2.78 / 5.3 / –
24 h, B, Winnipeg	0 / 350.3 / 6.31 / 3.9 / 21.8	0 / 350.3 / 6.38 / 3.9 / 30.2
Closes 22:00, B, Winnipeg	1 / 304.6 / 6.35 / 22.0 / 21.7	0 / 304.3 / 6.41 / 22.0 / 30.0

S2.11 Tower assumptions

Table S23. Whole-module tower water (m^3 yr^{-1}) and electricity (MWh yr^{-1}), Case B, by tower assumption.

Assumption	Phoenix	Las Vegas	Fresno	L. Angeles	S. Francisco	Miami	Chicago	Vancouver	Winnipeg
COC 2	1,952 / 15.5	1,894 / 15.5	1,832 / 15.5	1,796 / 15.5	1,752 / 15.5	1,897 / 15.5	1,684 / 15.5	1,697 / 15.5	1,578 / 15.5
COC 3 (central)	1,464 / 15.5	1,421 / 15.5	1,374 / 15.5	1,347 / 15.5	1,314 / 15.5	1,423 / 15.5	1,263 / 15.5	1,273 / 15.5	1,184 / 15.5
COC 6	1,171 / 15.5	1,137 / 15.5	1,099 / 15.5	1,078 / 15.5	1,051 / 15.5	1,138 / 15.5	1,011 / 15.5	1,018 / 15.5	947 / 15.5
Fan 0.004 kW per kW	1,464 / 12.4	1,421 / 12.4	1,374 / 12.4	1,347 / 12.4	1,314 / 12.4	1,423 / 12.4	1,263 / 12.4	1,273 / 12.4	1,184 / 12.4
Fan 0.016 kW per kW	1,464 / 21.8	1,421 / 21.8	1,374 / 21.8	1,347 / 21.8	1,314 / 21.8	1,423 / 21.8	1,263 / 21.8	1,273 / 21.8	1,184 / 21.8