Supplementary Materials

Effects of Street Trees on Building Facades: Vertical Temperature Patterns and Wall–Air Heat Exchange

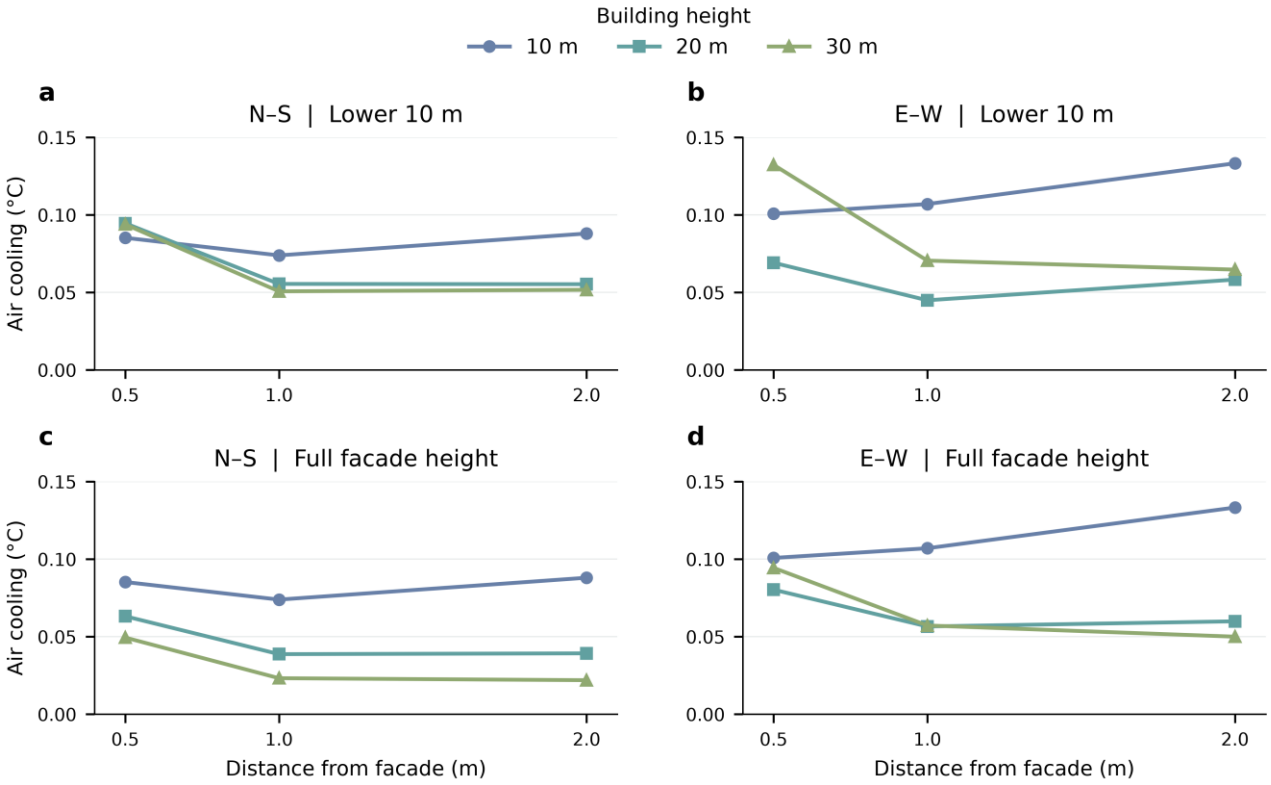


Figure S1. Daytime near-facade air cooling, G0−G2, at wall distances of 0.5, 1 and 2 m for 10, 20 and 30 m buildings. Upper panels average the lower 10 m of each facade; lower panels average the full building height. Values are averaged over both facade sides and the central 72 m, with daytime means calculated from 08:00 to 18:00.

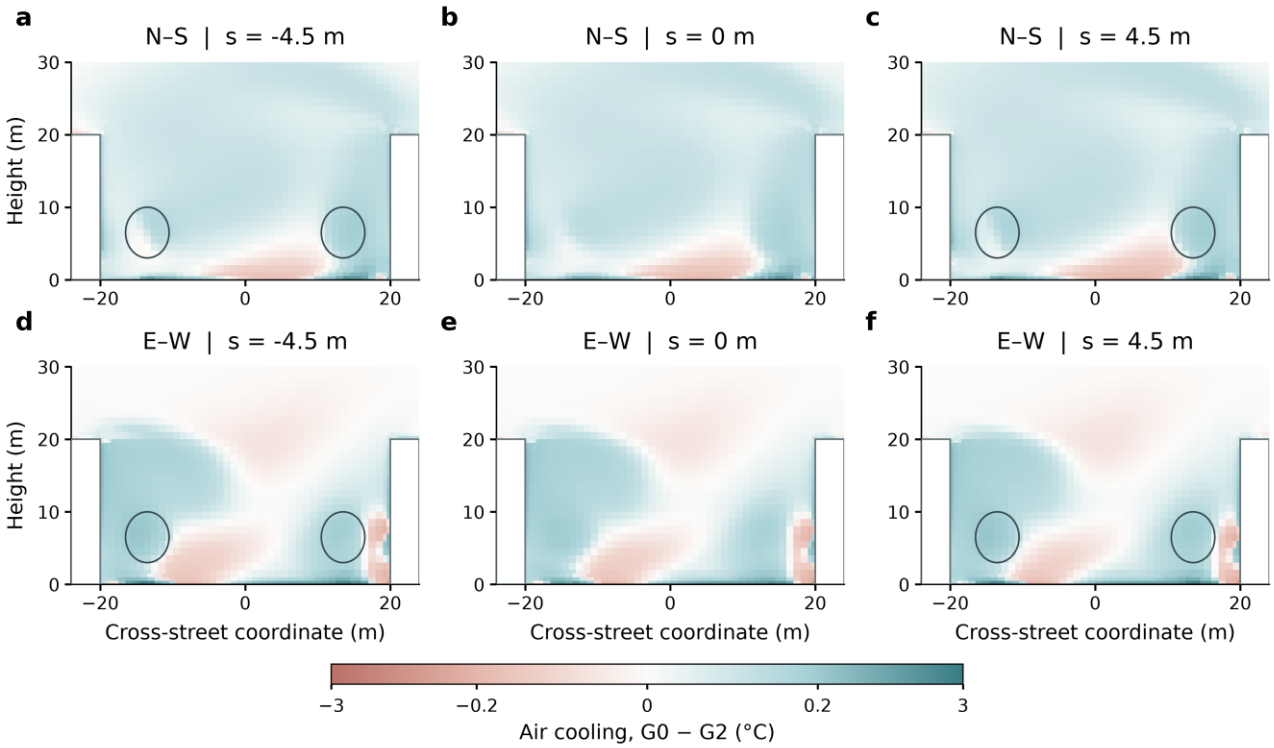


Figure S2. Transverse air-temperature differences, G0−G2, at 14:00 for H20. Sections at along-street coordinates s = −4.5 and 4.5 m pass through the two central tree pairs; s = 0 m lies in the gap. White blocks indicate buildings and ellipses crowns. The shared symmetric logarithmic colour scale is linear within ±0.05 °C.

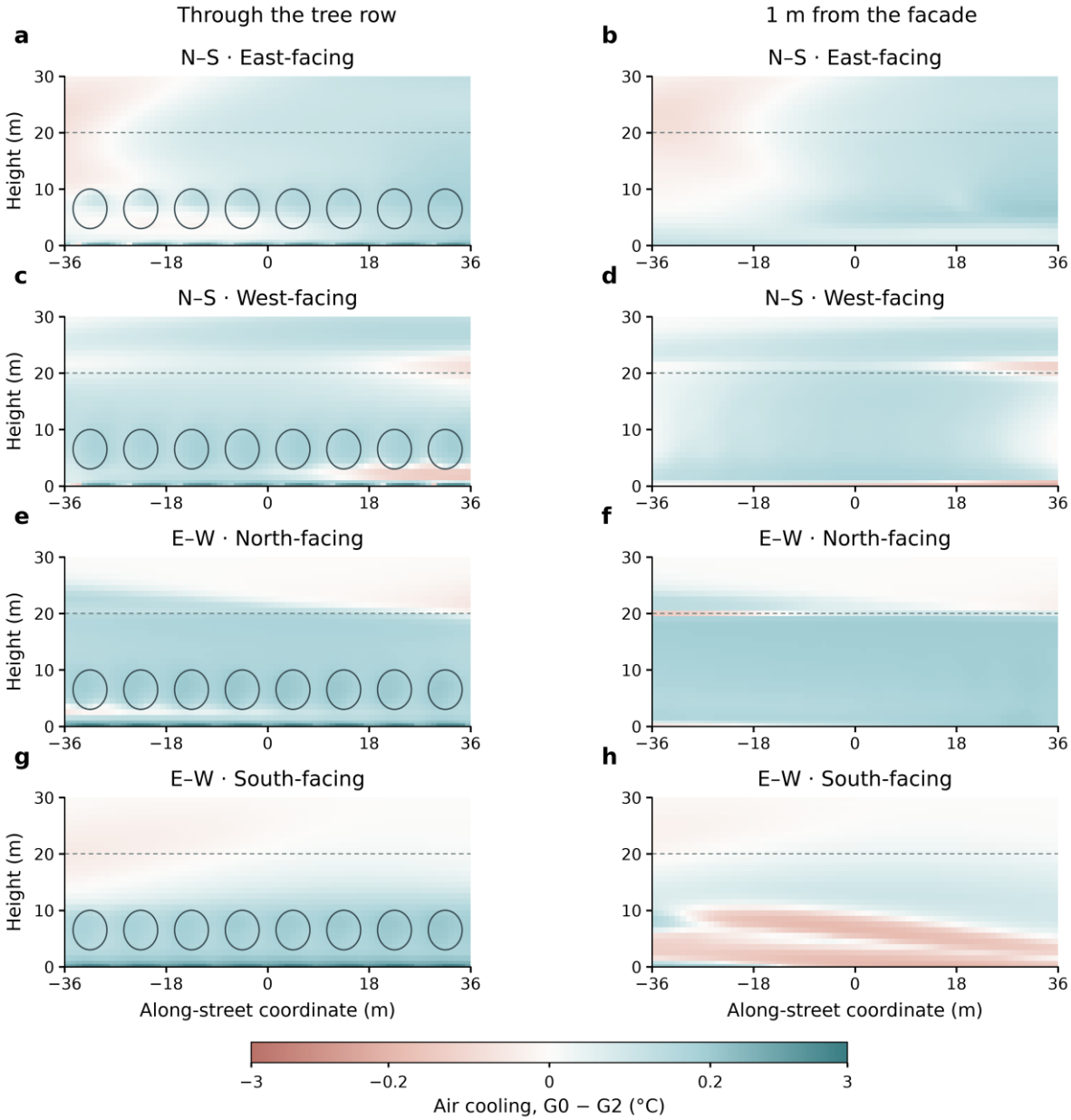


Figure S3. Longitudinal air-temperature differences, G0−G2, at 14:00 for H20 over the central 72 m. Ellipses indicate crowns; dashed lines mark the 20 m roof height. The shared symmetric logarithmic colour scale is linear within ±0.05 °C.

Table S1. Air-side wall-temperature differences for the E–W H20 G2 0–3 m bands over the central 72 m. Differences are test minus the 1 m reference.

Time	Mesh (m)	Facade	Mean diff. (°C)	MAE (°C)	RMSE (°C)
09:00	0.75	North	+0.244	0.281	0.321
09:00	0.75	South	+0.208	0.210	0.230
09:00	1.50	North	+0.323	0.348	0.424
09:00	1.50	South	+0.272	0.273	0.299
14:00	0.75	North	-0.020	0.099	0.140
14:00	0.75	South	+0.011	0.342	0.574
14:00	1.50	North	+0.101	0.142	0.178
14:00	1.50	South	+0.067	0.528	0.677
17:00	0.75	North	+0.025	0.110	0.158
17:00	0.75	South	+0.039	0.232	0.379
17:00	1.50	North	-0.005	0.145	0.196
17:00	1.50	South	-0.016	0.345	0.459

Comparisons use area overlaps between native wall faces.

Table S2. Daytime changes in the E–W 0–3 m wall energy budget at 9 m tree spacing. All differences are G0−G2; positive values denote reductions. Flux differences are in W m^{-2}.

Height (m)	Facade	ΔTs (°C)	ΔSW	ΔLW	ΔqH	Δqcond	Δqeff
10	North	-0.70	0.92	-7.26	-3.75	-2.53	-6.29
10	South	-0.28	1.57	-6.80	-4.89	-0.36	-5.24
20	North	-0.10	5.46	-4.46	0.09	0.81	0.90
20	South	-0.67	-0.12	-4.92	-2.47	-2.46	-4.93
30	North	0.49	9.42	-2.11	3.08	4.05	7.13
30	South	0.14	6.86	-0.67	4.39	1.69	6.08

SW and LW are saved shortwave and net longwave inputs. qH is sensible heat release, qcond is conduction into the wall, and qeff is the effective external input recovered from the coupled boundary condition. Means use the central 72 m and 08:00–18:00 trapezoidal weighting.

Table S3. Daytime whole-facade temperatures and heat exchange for all 16 cases.

Means cover the full building height within the central 72 m, using face-area weighting and trapezoidal integration from 08:00 to 18:00. NS and EW identify canyon orientation; facade directions are outward-facing. G0 is tree-free; G1, G2 and G3 have 13, 9 and 7 m tree spacing. H is building height in metres.

Case	Facade	Ts (°C)	Ta (°C)	h (W m^{-2} K^{-1})	qH (W m^{-2})	qcond (W m^{-2})	qeff (W m^{-2})
NS H10 G0	East	38.393	34.610	20.58	81.01	55.57	136.58
NS H10 G0	West	42.272	35.215	13.83	44.45	99.51	143.96
NS H10 G2	East	37.871	34.501	19.96	69.75	53.51	123.26
NS H10 G2	West	40.924	35.080	13.74	36.77	87.41	124.18
NS H20 G0	East	38.759	34.582	19.10	79.10	59.04	138.14
NS H20 G0	West	40.786	34.796	15.72	62.27	85.51	147.78
NS H20 G1	East	38.056	34.512	18.53	69.37	55.13	124.50
NS H20 G1	West	40.098	34.719	15.15	50.64	81.44	132.08
NS H20 G2	East	37.761	34.480	18.44	65.84	53.55	119.40
NS H20 G2	West	39.735	34.686	15.00	46.11	79.13	125.24
NS H20 G3	East	37.481	34.440	18.40	62.77	52.13	114.90
NS H20 G3	West	39.489	34.645	14.90	43.42	77.45	120.87
NS H30 G0	East	39.151	34.649	17.36	75.85	62.03	137.88
NS H30 G0	West	40.263	34.652	15.18	65.09	79.37	144.46
NS H30 G2	East	38.260	34.556	16.80	65.06	56.97	122.03
NS H30 G2	West	39.406	34.555	14.79	53.19	74.71	127.91
EW H10 G0	North	37.508	34.809	13.36	23.02	60.54	83.56
EW H10 G0	South	39.162	34.894	15.69	41.57	66.69	108.26
EW H10 G2	North	37.287	34.705	12.68	20.43	58.39	78.82
EW H10 G2	South	38.779	34.731	15.98	40.75	63.55	104.30
EW H20 G0	North	37.235	34.655	14.85	26.76	58.52	85.28
EW H20 G0	South	38.834	34.665	16.05	42.11	65.04	107.15
EW H20 G1	North	36.601	34.563	14.08	19.30	54.62	73.91
EW H20 G1	South	38.129	34.590	16.13	35.77	60.53	96.30
EW H20 G2	North	36.320	34.510	13.91	16.68	52.93	69.60
EW H20 G2	South	37.947	34.567	16.14	34.14	59.25	93.39
EW H20 G3	North	36.151	34.468	13.71	15.32	51.87	67.19
EW H20 G3	South	37.642	34.518	16.14	31.53	57.50	89.03
EW H30 G0	North	37.533	34.573	13.08	30.38	59.86	90.23
EW H30 G0	South	39.194	34.673	13.68	41.86	67.03	108.88
EW H30 G2	North	36.451	34.402	12.70	20.00	53.48	73.48
EW H30 G2	South	38.126	34.551	13.71	33.35	60.54	93.89

Ts is wall temperature; Ta is boundary-adjacent air temperature. h is the effective wall-to-cell heat-transfer coefficient; qH is heat release to air, qcond conduction into the wall, and qeff effective external input. Fluxes are evaluated facewise before averaging.

Table S4. Daytime facade responses to tree spacing at H20. N–S canyon.

Differences are G0−Gi at the same height and orientation. Positive values indicate cooling or reduced sensible heat release. Values use the central 72 m and the daytime weighting defined in Table S3. The 0–20 m band is the whole facade.

Spacing case	Facade	Wall band (m)	Wall cooling (°C)	Adjacent-air cooling (°C)	Sensible heat reduction (W m^{-2})
G1 (13 m)	East	0–3	0.883	0.152	11.95
G1 (13 m)	East	3–10	0.879	0.094	9.40
G1 (13 m)	East	10–20	0.525	0.028	9.30
G1 (13 m)	East	0–20	0.703	0.070	9.73
G2 (9 m)	East	0–3	1.235	0.195	17.19
G2 (9 m)	East	3–10	1.212	0.139	12.69
G2 (9 m)	East	10–20	0.777	0.048	12.48
G2 (9 m)	East	0–20	0.998	0.102	13.26
G3 (7 m)	East	0–3	1.778	0.282	23.29
G3 (7 m)	East	3–10	1.568	0.186	16.36
G3 (7 m)	East	10–20	0.924	0.068	14.22
G3 (7 m)	East	0–20	1.278	0.141	16.33
G1 (13 m)	West	0–3	1.043	0.204	6.41
G1 (13 m)	West	3–10	0.776	0.056	14.78
G1 (13 m)	West	10–20	0.520	0.055	10.98
G1 (13 m)	West	0–20	0.688	0.078	11.63
G2 (9 m)	West	0–3	1.670	0.285	10.35
G2 (9 m)	West	3–10	1.188	0.085	20.29
G2 (9 m)	West	10–20	0.770	0.076	15.02
G2 (9 m)	West	0–20	1.051	0.110	16.16
G3 (7 m)	West	0–3	2.175	0.370	13.44
G3 (7 m)	West	3–10	1.461	0.123	23.48
G3 (7 m)	West	10–20	0.918	0.105	17.23
G3 (7 m)	West	0–20	1.297	0.151	18.85

Table S4. Continued. E–W canyon.

Differences are G0−Gi at the same height and orientation. Positive values indicate cooling or reduced sensible heat release. Values use the central 72 m and the daytime weighting defined in Table S3. The 0–20 m band is the whole facade.

Spacing case	Facade	Wall band (m)	Wall cooling (°C)	Adjacent-air cooling (°C)	Sensible heat reduction (W m^{-2})
G1 (13 m)	North	0–3	0.067	0.069	1.12
G1 (13 m)	North	3–10	0.556	0.068	7.85
G1 (13 m)	North	10–20	0.858	0.115	9.09
G1 (13 m)	North	0–20	0.634	0.092	7.46
G2 (9 m)	North	0–3	-0.100	0.096	0.09
G2 (9 m)	North	3–10	0.914	0.119	11.37
G2 (9 m)	North	10–20	1.222	0.178	12.18
G2 (9 m)	North	0–20	0.916	0.145	10.08
G3 (7 m)	North	0–3	0.031	0.133	1.47
G3 (7 m)	North	3–10	1.102	0.160	13.03
G3 (7 m)	North	10–20	1.388	0.222	13.31
G3 (7 m)	North	0–20	1.084	0.187	11.44
G1 (13 m)	South	0–3	-0.403	-0.037	-0.60
G1 (13 m)	South	3–10	0.908	0.118	6.31
G1 (13 m)	South	10–20	0.895	0.078	8.45
G1 (13 m)	South	0–20	0.705	0.075	6.34
G2 (9 m)	South	0–3	-0.673	-0.048	-2.47
G2 (9 m)	South	3–10	1.185	0.156	8.12
G2 (9 m)	South	10–20	1.148	0.100	11.01
G2 (9 m)	South	0–20	0.888	0.097	7.97
G3 (7 m)	South	0–3	-0.458	0.016	-1.13
G3 (7 m)	South	3–10	1.596	0.225	11.28
G3 (7 m)	South	10–20	1.405	0.132	13.61
G3 (7 m)	South	0–20	1.192	0.147	10.59

Table S5. Daytime facade responses to building height at 9 m tree spacing.

Differences are G0−G2, with the averaging and sign conventions in Table S4. The 0–10 m interval compares the same physical wall height. Full-height bands are 0–10, 0–20 and 0–30 m for H10, H20 and H30; the H10 0–10 m band serves both purposes.

Case	Facade	Wall band (m)	Wall cooling (°C)	Adjacent-air cooling (°C)	Sensible heat reduction (W m^{-2})
NS H10 G2	East	0–3	0.510	0.120	14.24
NS H10 G2	East	0–10	0.522	0.108	11.26
NS H10 G2	West	0–3	1.832	0.208	4.81
NS H10 G2	West	0–10	1.348	0.135	7.68
NS H20 G2	East	0–3	1.235	0.195	17.19
NS H20 G2	East	0–10	1.219	0.156	14.04
NS H20 G2	East	0–20	0.998	0.102	13.26
NS H20 G2	West	0–3	1.670	0.285	10.35
NS H20 G2	West	0–10	1.332	0.145	17.31
NS H20 G2	West	0–20	1.051	0.110	16.16
NS H30 G2	East	0–3	1.397	0.149	15.77
NS H30 G2	East	0–10	1.426	0.200	14.37
NS H30 G2	East	20–30	0.360	0.024	8.77
NS H30 G2	East	0–30	0.891	0.093	10.79
NS H30 G2	West	0–3	1.830	0.253	13.41
NS H30 G2	West	0–10	1.428	0.126	17.35
NS H30 G2	West	20–30	0.354	0.080	7.38
NS H30 G2	West	0–30	0.857	0.096	11.90
EW H10 G2	North	0–3	-0.697	0.069	-3.75
EW H10 G2	North	0–10	0.221	0.104	2.59
EW H10 G2	South	0–3	-0.281	0.139	-4.89
EW H10 G2	South	0–10	0.383	0.162	0.82
EW H20 G2	North	0–3	-0.100	0.096	0.09
EW H20 G2	North	0–10	0.609	0.112	7.99
EW H20 G2	North	0–20	0.916	0.145	10.08
EW H20 G2	South	0–3	-0.673	-0.048	-2.47
EW H20 G2	South	0–10	0.628	0.094	4.94
EW H20 G2	South	0–20	0.888	0.097	7.97
EW H30 G2	North	0–3	0.495	0.213	3.08
EW H30 G2	North	0–10	1.302	0.221	12.28
EW H30 G2	North	20–30	0.775	0.121	6.64
EW H30 G2	North	0–30	1.082	0.171	10.38
EW H30 G2	South	0–3	0.140	-0.054	4.39
EW H30 G2	South	0–10	1.287	0.186	8.41
EW H30 G2	South	20–30	0.609	0.047	7.15
EW H30 G2	South	0–30	1.068	0.123	8.51

Table S6. Decomposition of daytime sensible heat reduction at H20 with 9 m tree spacing.

Both terms and the total use G0−G2 and are in W m^{-2}. The coefficient term and wall–air temperature-difference term follow Equation (2), evaluated on matched wall faces before averaging. Spatial and time weighting follow Table S3.

Canyon	Facade	Wall band (m)	Coefficient term	Temperature-difference term	Total sensible heat reduction
NS	East	0–3	1.36	15.83	17.19
NS	East	3–10	1.02	11.67	12.69
NS	East	10–20	2.47	10.00	12.48
NS	East	0–20	1.80	11.46	13.26
NS	West	0–3	0.64	9.71	10.35
NS	West	3–10	6.27	14.02	20.29
NS	West	10–20	5.91	9.11	15.02
NS	West	0–20	5.25	10.92	16.16
EW	North	0–3	2.09	-2.00	0.09
EW	North	3–10	3.33	8.04	11.37
EW	North	10–20	1.80	10.38	12.18
EW	North	0–20	2.38	7.70	10.08
EW	South	0–3	2.38	-4.85	-2.47
EW	South	3–10	-0.59	8.71	8.12
EW	South	10–20	-1.36	12.36	11.01
EW	South	0–20	-0.53	8.50	7.97

Table S7. Hourly lower-wall cooling at H20 with 9 m tree spacing.

Values are G0−G2 wall-temperature differences (°C), area-weighted over the 0–3 m band and central 72 m. Hours use the model clock; negative values indicate warming.

Hour	N–S East-facing	N–S West-facing	E–W North-facing	E–W South-facing
08:00	2.834	-0.147	-0.132	-0.477
09:00	4.248	-0.060	-0.194	-0.532
10:00	2.443	-0.096	-0.204	-0.625
11:00	1.226	-0.146	-0.243	-0.607
12:00	0.577	-0.334	-0.166	-0.658
13:00	0.368	-0.250	-0.223	-0.717
14:00	0.338	0.299	-0.274	-0.718
15:00	0.462	4.638	-0.272	-0.739
16:00	0.600	7.060	-0.245	-0.762
17:00	0.597	4.900	-0.070	-0.760
18:00	0.148	1.521	1.905	-0.751