# Online Resource 2. Acoustic results and sensitivities

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*.

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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.

Fan noise is the source–receiver screening calculation of Section 2.8 of the main text: sound power scaled from one datasheet level by coil size and fan speed, hemispherical spreading, no ground, barrier, air absorption, directivity or tonal correction, and no pump noise. The levels below are therefore indicative for comparing the two coolers and are not a compliance assessment. Both coolers use the coupled coil model with the water leaving at 45 °C.

*Dispatch configurations.* Two dispatches appear in this document and are always labelled. The **quiet-hours dispatch** is the configuration of the main article's headline results: between 22:00 and 07:00 the PVT array keeps its rejection duty in hours that are already light (summer dawn), so the coil fans stay off for the whole regulatory night. The **ordinary dispatch** ends the PVT duty at sunrise, so on summer mornings the coil fans can start before 07:00; it is retained for comparison. Levels for the quiet-hours dispatch are taken from the same runs as Tables 3 and 4 of the main article; the regulatory night is 22:00–07:00 throughout.

## S3 Levels

**Table S24.** Fan noise at 10 m, Case A, **quiet-hours dispatch** (main-article configuration), 24-hour laundromat: equivalent continuous levels by day (07:00–22:00) and night (22:00–07:00), dB(A), with fan-off hours silent (– = no fan operation in the period), and fan hours between 22:00 and 07:00 for the central and measurement-anchored inputs.

| Site | Proposed: day / night $L_{Aeq}$ | Proposed: fan h 22–07, central / anchored | Dry cooler: day / night $L_{Aeq}$ | Dry cooler: fan h 22–07 | Dry: night h > ambient + 5 dB | Day difference, proposed − dry (dB) |
|---|---|---|---|---|---|---|
| Phoenix | 11.8 / – | 0 / 0 | 11.2 / 15.6 | 1,044 | 0 | 0.6 |
| Las Vegas | 12.0 / – | 0 / 0 | 10.9 / 14.6 | 1,044 | 0 | 1.1 |
| Fresno | 12.0 / – | 0 / 0 | 9.6 / 15.5 | 1,044 | 0 | 2.4 |
| Los Angeles | 12.0 / – | 0 / 0 | 16.9 / 29.2 | 1,044 | 0 | -4.9 |
| San Francisco | 11.9 / – | 0 / 0 | 14.0 / 26.0 | 1,044 | 0 | -2.1 |
| Miami | 12.0 / – | 0 / 0 | 16.4 / 28.4 | 1,044 | 2 | -4.5 |
| Chicago | 12.0 / – | 0 / 0 | 12.6 / 22.8 | 1,044 | 0 | -0.6 |
| Vancouver | 11.2 / – | 0 / 0 | 15.9 / 28.4 | 1,044 | 2 | -4.7 |

| Site | Proposed: day / night $L_{Aeq}$ | Proposed: fan h 22–07, central / anchored | Dry cooler: day / night $L_{Aeq}$ | Dry cooler: fan h 22–07 | Dry: night h > ambient + 5 dB | Day difference, proposed − dry (dB) |
|---|---|---|---|---|---|---|
| Winnipeg | 11.1 / – | 0 / 0 | 11.0 / 21.5 | 1,044 | 0 | 0.1 |

**Table S25.** Fan noise at 10 m, Case B, **quiet-hours dispatch** (main-article configuration), 24-hour laundromat: equivalent continuous levels by day (07:00–22:00) and night (22:00–07:00), dB(A), with fan-off hours silent (– = no fan operation in the period), and fan hours between 22:00 and 07:00 for the central and measurement-anchored inputs.

| Site | Proposed: day / night $L_{Aeq}$ | Proposed: fan h 22–07, central / anchored | Dry cooler: day / night $L_{Aeq}$ | Dry cooler: fan h 22–07 | Dry: night h > ambient + 5 dB | Day difference, proposed − dry (dB) |
|---|---|---|---|---|---|---|
| Phoenix | 40.0 / – | 0 / 0 | 30.1 / 26.2 | 3,285 | 0 | 9.8 |
| Las Vegas | 36.6 / – | 0 / 1 | 29.0 / 25.0 | 3,285 | 0 | 7.6 |
| Fresno | 30.4 / – | 0 / 0 | 29.0 / 26.5 | 3,285 | 0 | 1.4 |
| Los Angeles | 22.3 / – | 0 / 0 | 34.9 / 40.8 | 3,285 | 618 | -12.6 |
| San Francisco | 21.3 / – | 0 / 0 | 32.0 / 37.5 | 3,285 | 20 | -10.7 |
| Miami | 28.1 / – | 0 / 0 | 34.8 / 40.1 | 3,285 | 464 | -6.6 |
| Chicago | 23.9 / – | 0 / 0 | 30.7 / 34.1 | 3,285 | 48 | -6.8 |
| Vancouver | 20.8 / – | 0 / 0 | 33.8 / 39.9 | 3,285 | 436 | -13.0 |
| Winnipeg | 21.8 / – | 0 / 0 | 29.3 / 33.1 | 3,285 | 20 | -7.6 |

**Table S25a.** For comparison, the **ordinary dispatch** (PVT duty ends at sunrise), central inputs: proposed system's night (22:00–07:00) equivalent level, dB(A), and its fan hours between sunset and sunrise. The non-zero levels come from coil operation on summer mornings before 07:00, which the quiet-hours dispatch removes.

| Site | Case A: night $L_{Aeq}$ / fan h | Case B: night $L_{Aeq}$ / fan h |
|---|---|---|
| Phoenix | 9.1 / 0 | 26.7 / 0 |
| Las Vegas | 11.4 / 0 | 26.8 / 0 |
| Fresno | 10.1 / 0 | 20.3 / 0 |
| Los Angeles | 10.7 / 0 | 19.5 / 0 |
| San Francisco | 9.6 / 0 | 16.4 / 0 |
| Miami | 9.1 / 0 | 23.9 / 0 |
| Chicago | 10.8 / 0 | 21.7 / 0 |
| Vancouver | 8.8 / 0 | 16.6 / 0 |
| Winnipeg | 8.2 / 0 | 15.8 / 0 |

Table S26 gives the levels while the fans run, hour by hour, against the design-sized dry cooler, which carries the same residual unaided at the 0.4% design temperature.

**Table S26.** Levels while running at 10 m: hours with fans on, energy-mean and maximum hourly level (dB(A)), and the mean difference in hours when both run.

| Case, site | Hybrid: h / mean / max | Dry: h (night) / mean / max | Hybrid − dry, both on (dB) | Size index hybrid / dry (kW K$^{-1}$) |
|---|---|---|---|---|
| A, Phoenix | 841 / 19.9 / 19.9 | 1,931 (1,044) / 19.9 / 32.7 | 0.9 | 3.0 / 2.5 |
| A, Las Vegas | 887 / 19.9 / 19.9 | 1,931 (1,044) / 19.3 / 28.5 | 1.2 | 3.0 / 2.2 |
| A, Fresno | 881 / 19.9 / 19.9 | 1,931 (1,044) / 19.3 / 29.8 | 2.6 | 3.0 / 1.6 |
| A, San Francisco | 867 / 19.9 / 19.9 | 1,931 (1,044) / 28.8 / 39.7 | 0.6 | 3.0 / 0.8 |
| A, Miami | 886 / 19.9 / 19.9 | 1,931 (1,044) / 31.2 / 43.7 | -1.0 | 3.0 / 1.1 |
| A, Chicago | 887 / 19.9 / 19.9 | 1,931 (1,044) / 25.8 / 41.5 | 2.3 | 3.0 / 1.0 |
| A, Los Angeles | 887 / 19.9 / 19.9 | 1,931 (1,044) / 31.9 / 43.2 | -1.1 | 3.0 / 0.8 |
| A, Vancouver | 738 / 19.9 / 19.9 | 1,931 (1,044) / 31.1 / 44.0 | 0.2 | 3.0 / 0.7 |
| A, Winnipeg | 721 / 19.9 / 19.9 | 1,931 (1,044) / 24.5 / 41.4 | 2.8 | 3.0 / 0.9 |
| B, Phoenix | 4,210 / 41.1 / 58.1 | 8,760 (3,285) / 29.0 / 56.3 | 3.8 | 4.0 / 6.9 |
| B, Las Vegas | 3,993 / 38.0 / 58.1 | 8,760 (3,285) / 27.9 / 58.0 | 2.5 | 4.0 / 6.3 |
| B, Fresno | 3,993 / 31.7 / 50.8 | 8,760 (3,285) / 28.2 / 48.8 | 0.6 | 4.0 / 4.4 |
| B, San Francisco | 4,050 / 22.6 / 32.9 | 8,760 (3,285) / 34.9 / 45.2 | -6.3 | 4.0 / 2.3 |
| B, Miami | 4,205 / 29.3 / 40.2 | 8,760 (3,285) / 37.5 / 48.9 | -4.2 | 4.0 / 3.0 |
| B, Chicago | 4,051 / 25.2 / 40.2 | 8,760 (3,285) / 32.3 / 47.8 | -2.3 | 4.0 / 2.9 |
| B, Los Angeles | 4,015 / 23.6 / 33.1 | 8,760 (3,285) / 38.1 / 48.2 | -8.2 | 4.0 / 2.2 |
| B, Vancouver | 3,919 / 22.2 / 31.4 | 8,760 (3,285) / 37.1 / 48.4 | -7.1 | 4.0 / 2.0 |
| B, Winnipeg | 3,994 / 23.1 / 36.7 | 8,760 (3,285) / 31.1 / 46.4 | -2.2 | 4.0 / 2.6 |

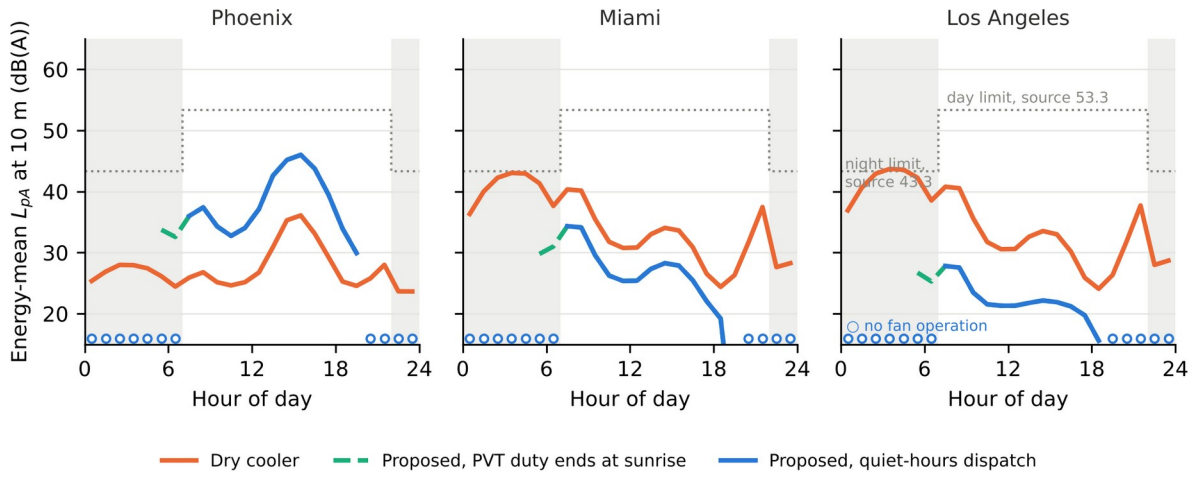


**Fig. S8.** Annual energy-mean hourly fan-noise level at 10 m by hour of day, Case B: dry cooler, proposed system with the ordinary dispatch (PVT duty ends at sunrise) and proposed system with the quiet-hours dispatch (main-article configuration).

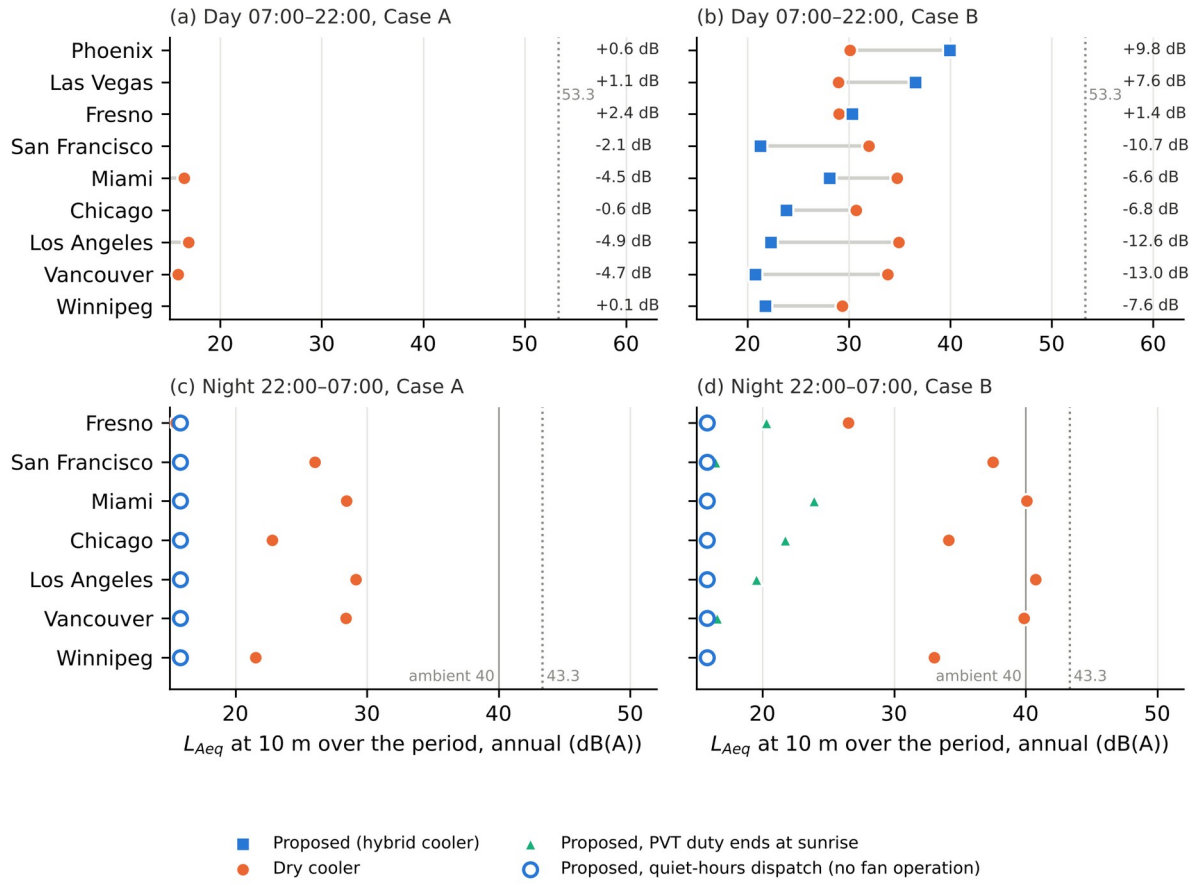


**Fig. S9.** Day (07:00–22:00) and night (22:00–07:00) equivalent continuous fan-noise levels at 10 m by climate. Day panels and the night markers labelled quiet-hours use the quiet-hours dispatch; the night markers labelled 'PVT duty ends at sunrise' use the ordinary dispatch.

## S4 Sensitivities

**Table S27.** Acoustic sensitivity, Case A, ordinary dispatch (the day-time difference and the dry-cooler level do not depend on the night dispatch of the proposed system): day-time difference (proposed minus dry cooler, dB) / dry-cooler night $L_{Aeq}$ (dB(A)).

| Assumption | Phoenix | Las Vegas | Fresno | L. Angeles | S. Francisco | Miami | Chicago | Vancouver | Winnipeg |
|---|---|---|---|---|---|---|---|---|---|
| Receiver at 25 m | 0.6 / 7.6 | 1.1 / 6.7 | 2.4 / 7.5 | -4.9 / 21.2 | -2.1 / 18.1 | -4.5 / 20.5 | -0.6 / 14.9 | -4.7 / 20.5 | 0.1 / 13.6 |
| Receiver at 50 m | 0.6 / 1.6 | 1.1 / 0.7 | 2.4 / 1.5 | -4.9 / 15.2 | -2.1 / 12.0 | -4.5 / 14.4 | -0.6 / 8.8 | -4.7 / 14.4 | 0.1 / 7.6 |
| Fan-law exponent 40 | 0.6 / 22.0 | 1.2 / 21.3 | 2.5 / 21.5 | -2.3 / 31.3 | -0.2 / 28.9 | -2.2 / 31.0 | 1.0 / 26.2 | -2.1 / 30.6 | 1.3 / 25.2 |
| Fan-law exponent 60 | 0.6 / 9.3 | 1.1 / 8.0 | 2.3 / 9.7 | -7.6 / 27.1 | -4.2 / 23.2 | -6.9 / 26.0 | -2.5 / 19.7 | -7.4 / 26.4 | -1.5 / 18.2 |
| Pad increment 0 dB | 0.6 / 15.6 | 1.1 / 14.6 | 2.4 / 15.5 | -4.9 / 29.2 | -2.1 / 26.0 | -4.5 / 28.4 | -0.6 / 22.8 | -4.7 / 28.4 | 0.1 / 21.5 |
| Pad increment 4 dB | 0.6 / 15.6 | 1.1 / 14.6 | 2.4 / 15.5 | -4.9 / 29.2 | -2.1 / 26.0 | -4.5 / 28.4 | -0.6 / 22.8 | -4.7 / 28.4 | 0.1 / 21.5 |

**Table S28.** Acoustic sensitivity, Case B, ordinary dispatch (the day-time difference and the dry-cooler level do not depend on the night dispatch of the proposed system): day-time difference (proposed minus dry cooler, dB) / dry-cooler night $L_{Aeq}$ (dB(A)).

| Assumption | Phoenix | Las Vegas | Fresno | L. Angeles | S. Francisco | Miami | Chicago | Vancouver | Winnipeg |
|---|---|---|---|---|---|---|---|---|---|
| Receiver at 25 m | 9.8 / 18.3 | 7.6 / 17.0 | 1.4 / 18.6 | -12.6 / 32.8 | -10.7 / 29.6 | -6.6 / 32.1 | -6.8 / 26.2 | -13.0 / 31.9 | -7.6 / 25.1 |
| Receiver at 50 m | 9.8 / 12.3 | 7.6 / 11.0 | 1.4 / 12.5 | -12.6 / 26.8 | -10.7 / 23.5 | -6.6 / 26.1 | -6.8 / 20.2 | -13.0 / 25.9 | -7.6 / 19.1 |
| Fan-law exponent 40 | 6.9 / 32.4 | 5.2 / 31.4 | 0.6 / 32.2 | -9.4 / 43.0 | -7.9 / 40.4 | -5.2 / 42.6 | -4.9 / 37.5 | -9.5 / 42.1 | -5.3 / 36.6 |
| Fan-law exponent 60 | 12.0 / 20.3 | 9.2 / 18.7 | 2.1 / 21.0 | -15.8 / 38.7 | -13.6 / 34.7 | -8.1 / 37.6 | -8.8 / 31.0 | -16.8 / 37.8 | -10.1 / 29.8 |
| Pad increment 0 dB | 9.2 / 26.2 | 7.0 / 25.0 | 1.4 / 26.5 | -12.6 / 40.8 | -10.7 / 37.5 | -6.6 / 40.1 | -6.8 / 34.1 | -13.0 / 39.9 | -7.6 / 33.1 |
| Pad increment 4 dB | 10.6 / 26.2 | 8.4 / 25.0 | 1.4 / 26.5 | -12.6 / 40.8 | -10.7 / 37.5 | -6.6 / 40.1 | -6.8 / 34.1 | -13.0 / 39.9 | -7.6 / 33.1 |

**Table S29.** PVT capacity uncertainty with the quiet-hours dispatch, Case A: night fan hours of the proposed system / its night $L_{Aeq}$ (dB(A)).

| PVT capacity | Phoenix | Las Vegas | Fresno | L. Angeles | S. Francisco | Miami | Chicago | Vancouver | Winnipeg |
|---|---|---|---|---|---|---|---|---|---|
| Full × 0.74 | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – |
| Full × 0.50 | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – |
| Bare × 0.74 (anchored) | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – |
| Bare × 0.50 | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – |

**Table S30.** PVT capacity uncertainty with the quiet-hours dispatch, Case B: night fan hours of the proposed system / its night $L_{Aeq}$ (dB(A)).

| PVT capacity | Phoenix | Las Vegas | Fresno | L. Angeles | S. Francisco | Miami | Chicago | Vancouver | Winnipeg |
|---|---|---|---|---|---|---|---|---|---|
| Full × 0.74 | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – |
| Full × 0.50 | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – |
| Bare × 0.74 (anchored) | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – | 0 / – |
| Bare × 0.50 | 14 / -2.6 | 15 / -2.3 | 36 / 1.6 | 0 / – | 0 / – | 60 / 3.8 | 61 / 3.8 | 99 / 5.9 | 39 / 1.9 |

**Table S31.** Coil rating as a design alternative, Case B, quiet-hours dispatch: installed coil area ($m^2$), rejection electricity (MWh $yr^{-1}$) and day-time $L_{Aeq}$ at 10 m (dB(A)).

| Site | 40 kW (central) | 70 kW | 100 kW |
|---|---|---|---|
| Phoenix | 2.7; 3.77; 40.0 | 4.7; 3.54; 29.4 | 6.8; 3.53; 25.3 |

| Site | 40 kW (central) | 70 kW | 100 kW |
|---|---|---|---|
| Las Vegas | 2.7; 3.63; 36.6 | 4.7; 3.51; 26.8 | 6.8; 3.52; 24.3 |
| Fresno | 2.7; 3.53; 30.4 | 4.7; 3.49; 23.0 | 6.8; 3.51; 23.8 |
| Los Angeles | 2.7; 3.47; 22.3 | 4.7; 3.49; 22.2 | 6.8; 3.51; 23.8 |
| San Francisco | 2.7; 3.46; 21.3 | 4.7; 3.49; 22.3 | 6.8; 3.52; 23.8 |
| Miami | 2.7; 3.52; 28.1 | 4.7; 3.49; 22.6 | 6.8; 3.52; 24.0 |
| Chicago | 2.7; 3.48; 23.9 | 4.7; 3.49; 22.3 | 6.8; 3.52; 23.8 |
| Vancouver | 2.7; 3.46; 20.8 | 4.7; 3.48; 22.1 | 6.8; 3.51; 23.7 |
| Winnipeg | 2.7; 3.47; 21.8 | 4.7; 3.49; 22.2 | 6.8; 3.51; 23.8 |

**Table S32.** Upper bound for flushing the PVT film circuit, quiet-hours dispatch, Case B: weeks in which the film ran, weeks already flushed for the pads, and extra flush water ($m^3$ $yr^{-1}$) and electricity (MWh $yr^{-1}$).

| Site | Film weeks | Pad-flush weeks | Extra water | Extra electricity |
|---|---|---|---|---|
| Phoenix | 7 | 7 | 0.6 | 0.01 |
| Las Vegas | 5 | 2 | 0.8 | 0.02 |
| Fresno | 0 | 0 | 0.0 | 0.00 |
| Los Angeles | 0 | 0 | 0.0 | 0.00 |
| San Francisco | 0 | 0 | 0.0 | 0.00 |
| Miami | 0 | 0 | 0.0 | 0.00 |
| Chicago | 0 | 0 | 0.0 | 0.00 |
| Vancouver | 0 | 0 | 0.0 | 0.00 |
| Winnipeg | 0 | 0 | 0.0 | 0.00 |