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Background

Policymakers and transit agencies have set up goals to accelerate the transition to zero-emission bus fleets. To assist in this transition we first provide a bi-objective optimization model which aims to minimize battery electric bus (BEB) and charging station procurement costs and maximize environmental equity for disadvantaged populations. Secondly, we provide a visualization platform, referred to as BEBExplorer, which allows users to explore deployment plans generated by the model. By use of our model and visualization platform, decision-makers can create strategies for transitioning towards zero-emissions fleets and gain a deep understanding of how they will work in practice.

Optimization Model

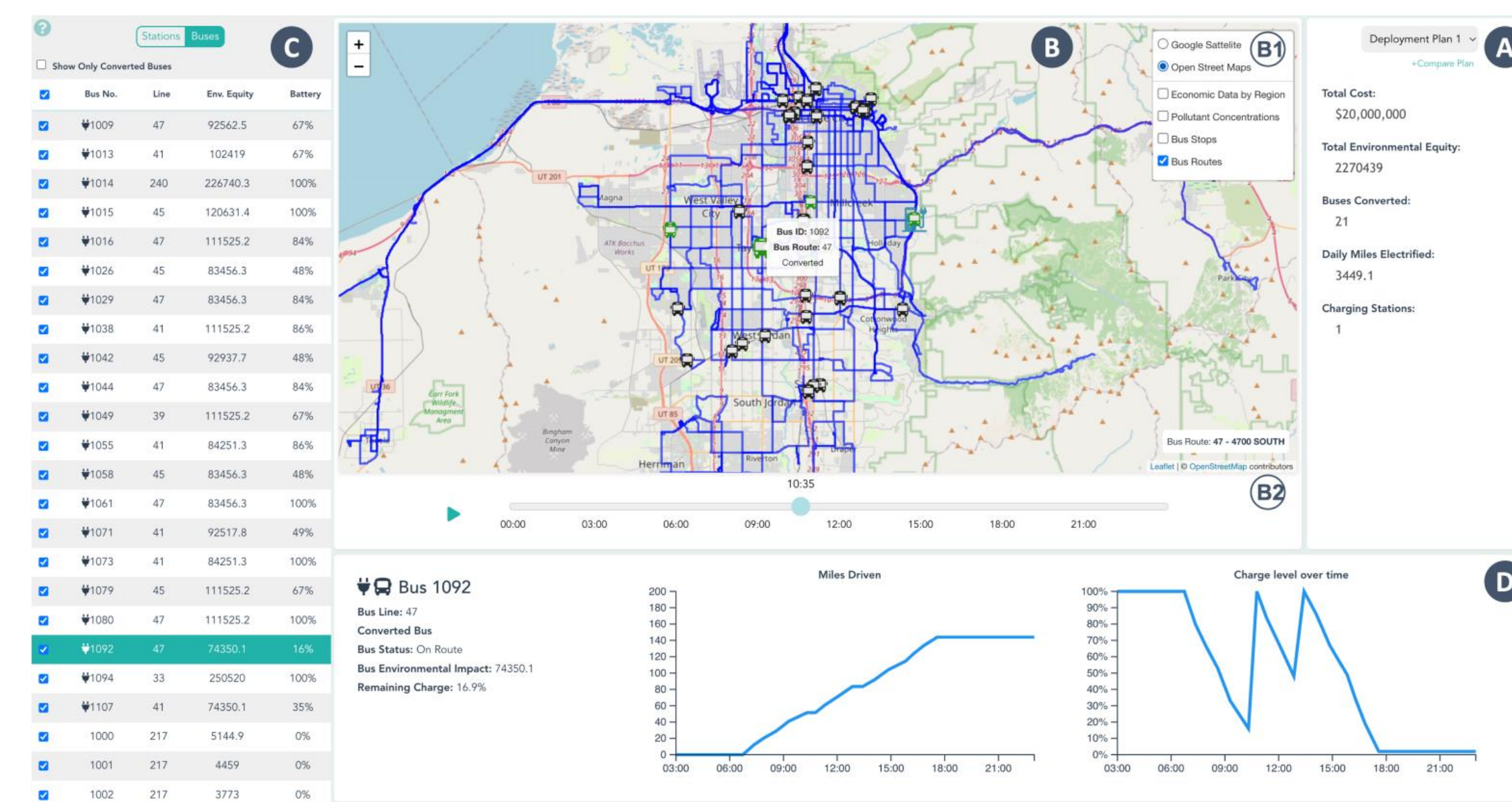
$$\max \sum_i E_i Z_i$$

$$\max \sum_i C^B Z_i + \sum_m C_m^O Y_m^O + \sum_n C_n^I Y_n^I$$

E_i : Environmental equity gained by replacing bus l
 Z_i : 1 if bus l is replaced with BEB, 0 otherwise
 C^B : Cost of purchasing 1 BEB
 C_m^O : Cost of building an on-route charging station at m
 Y_m^O : Number of on-route charging stations built at m
 C_n^I : Cost of building an in-depot charging station at n
 Y_n^I : Number of in-depot charging stations built at n

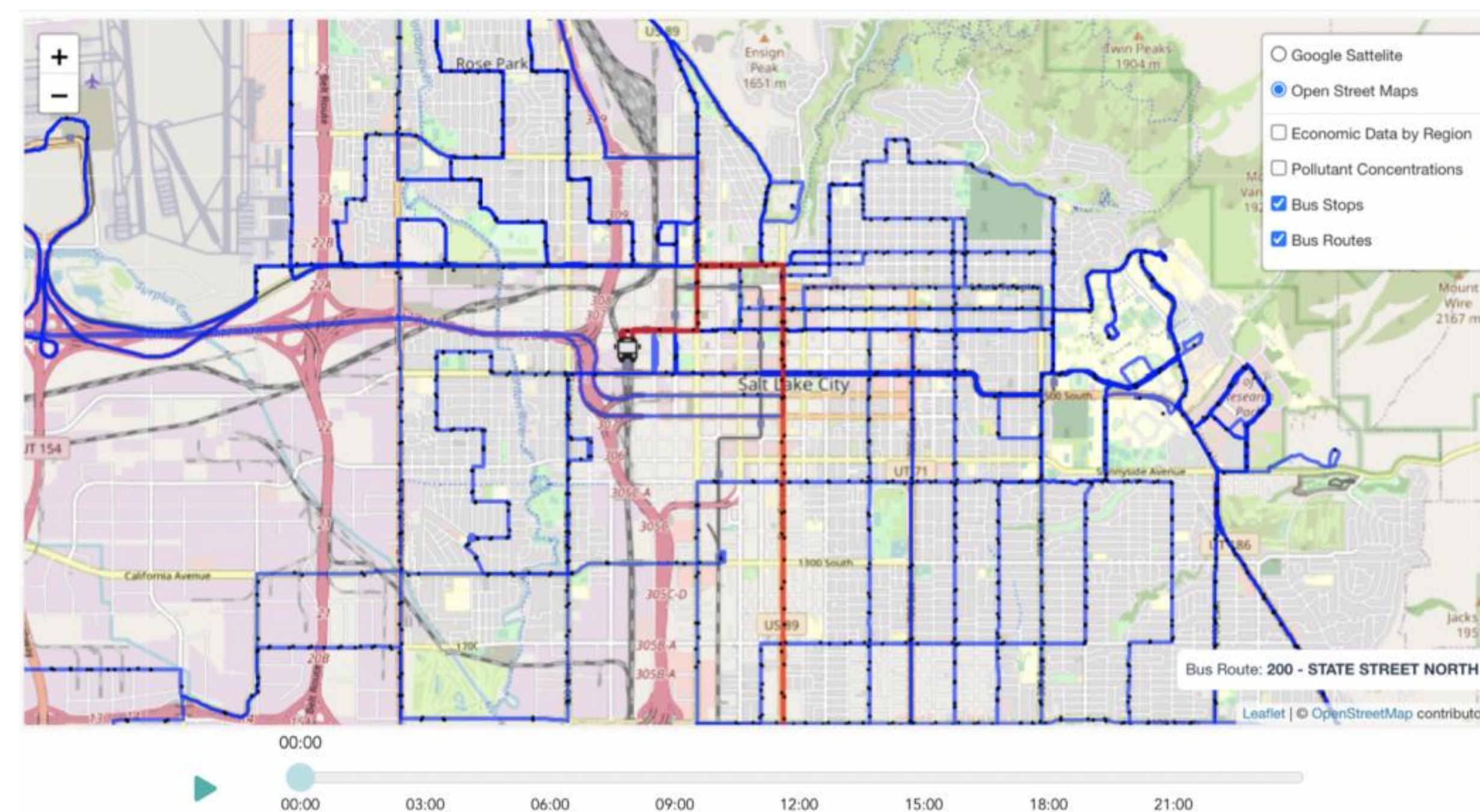
By maximizing these objectives subject to constraints not listed we determine the number of on-route and in-depot charging stations to build at each location m and n respectively, the distance traveled by busses between charging stations, where busses should be charged, and how many busses should be converted. These are calculated to minimize cost and maximize environmental equity.

BEBExplorer: Main View

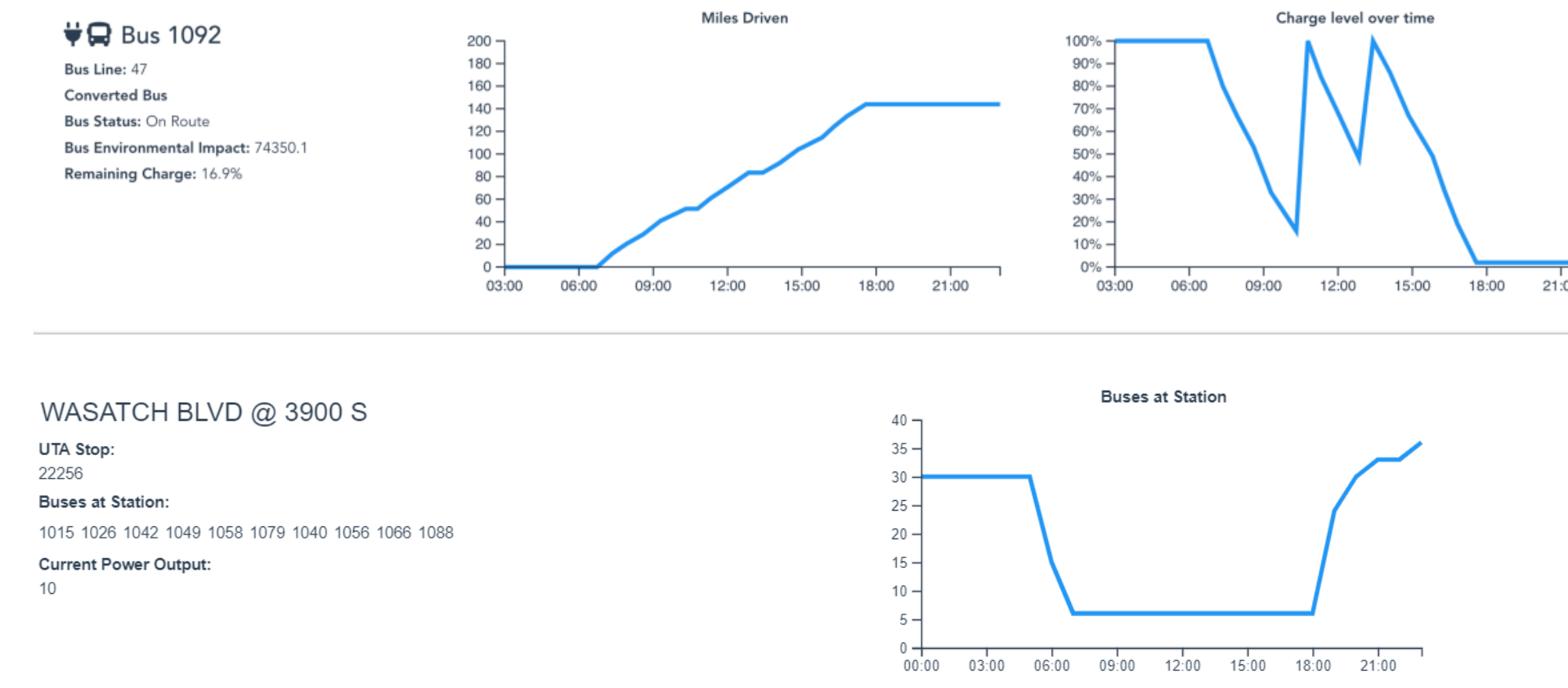


<https://gracious-heisenberg-a8a687.netlify.app/>

BEBExplorer: Map Interactivity



BEBExplorer: Bus/Charging Station Specific View



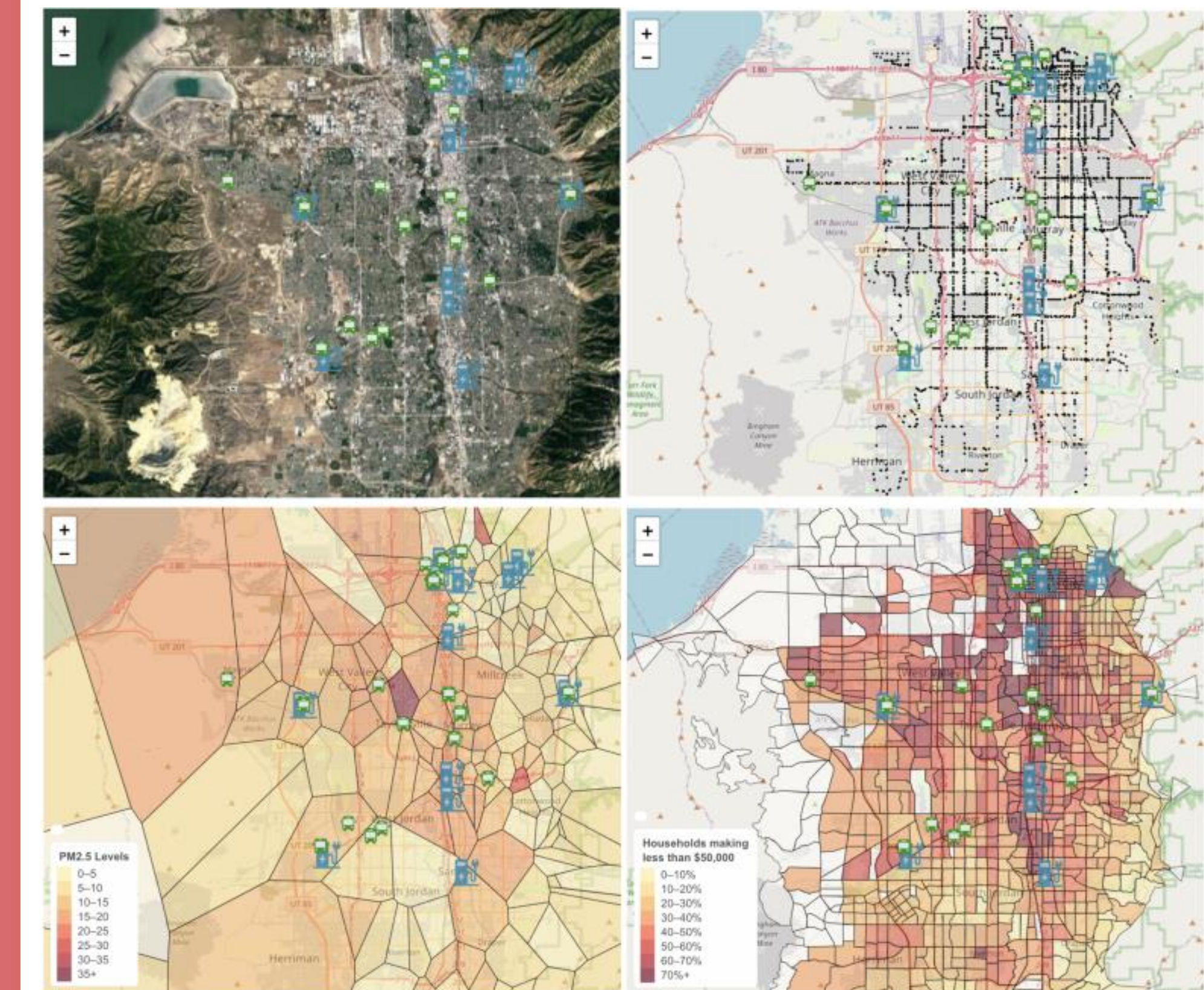
BEBExplorer: Plan Comparison

Deployment Plan 1	Deployment Plan 2
Total Cost: \$20,000,000	Total Cost: Selected Plan: \$20,000,000 Comparison: \$60,000,000
Total Environmental Equity: 2270439	Total Environmental Equity: Selected Plan: 2270439 Comparison: 4437257.6
Buses Converted: 21	Buses Converted: Selected Plan: 21 Comparison: 63
Daily Miles Electrified: 3449.1	Daily Miles Electrified: Selected Plan: 3449.1 Comparison: 7951.5
Charging Stations: 1	Charging Stations: Selected Plan: 1 Comparison: 5

Acknowledgement

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BEBExplorer: Map Views & Overlays



Conclusion

- Our optimization model allows for the generation of deployment strategies
- The BEBExplorer platform provides spatio-temporal visualizations of potential deployment strategies
- The use of overlays can assist in the analysis of economic and ecological impact of deployment
- Different deployment strategies can be compared on the BEBExplorer platform

Future Work

- Provide a mechanism for modifying bus routes in the BEBExplorer
- Display accurate bus locations on the map view for varying bus schedules

