# An analytical framework for bus fleet electrification and e-bus charging station planning: A case study of Gainesville Regional Transit System

UF Transportation Institute UNIVERSITY of FLORIDA

Anran 'Kelly' Zheng [1] (anranzheng@ufl.edu) Xiang 'Jacob' Yan [1] (xiangyan@ufl.edu)

[1]Department of Civil and Coastal Engineering, University of Florida

JUST GREEN TRANSPORTATION LAB

## Background

- The bus fleet electrification involves two major considerations: **route prioritization** and **planning of electric bus charging stations (EBCS)**.
- Few existing research has focused on route prioritization. And the planning of EBCS is usually based on the assumption of a fully electrified bus fleet. In reality, bus fleet electrification is a **gradual process** (one or several e-buses are added at a time). There is a lack of generalizable methodology to guide the bus fleet electrification process.

## Highlights

- An **analytical framework** for bus electrification and charging station planning is proposed to **plan future EBCS** based on a current non-electrified bus fleet.
- The **energy consumption estimation model** is built with **GTFS dataset**, which generates **a more accurate estimation** of energy consumption and helps plan the electrification of the existing non-electrified bus network.
- The **bus service gap time** is considered in the location selection of EBCS to ensure sufficient charging time and punctuality.

## Study area and assumptions

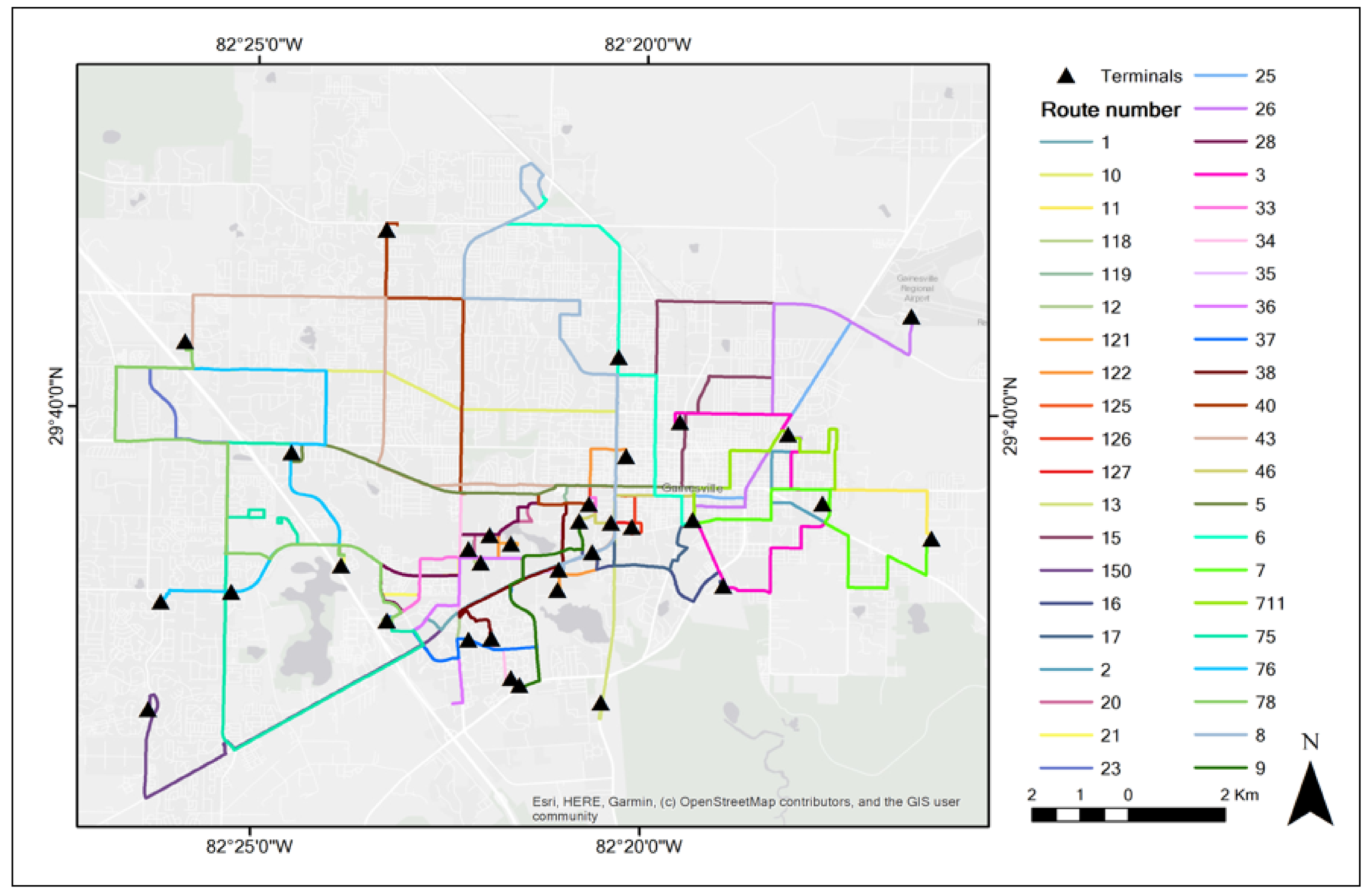



Figure 1. Case study: Regional Transit System (RTS) bus service routes in Gainesville, Florida

**Assumptions:**

- The **battery capacity** of every e-bus is assumed as **150Kwh**.
- When a fully-charged e-bus has consumed about **80%** of its battery capacity (120 Kwh), it needs **recharging fully** at EBCS before continuing its trip, which takes about **15 min**.
- All the EBCS should be installed within **5 min driving range** from start & end stops.
- All buses will be fully charged at night.

## Analytical framework

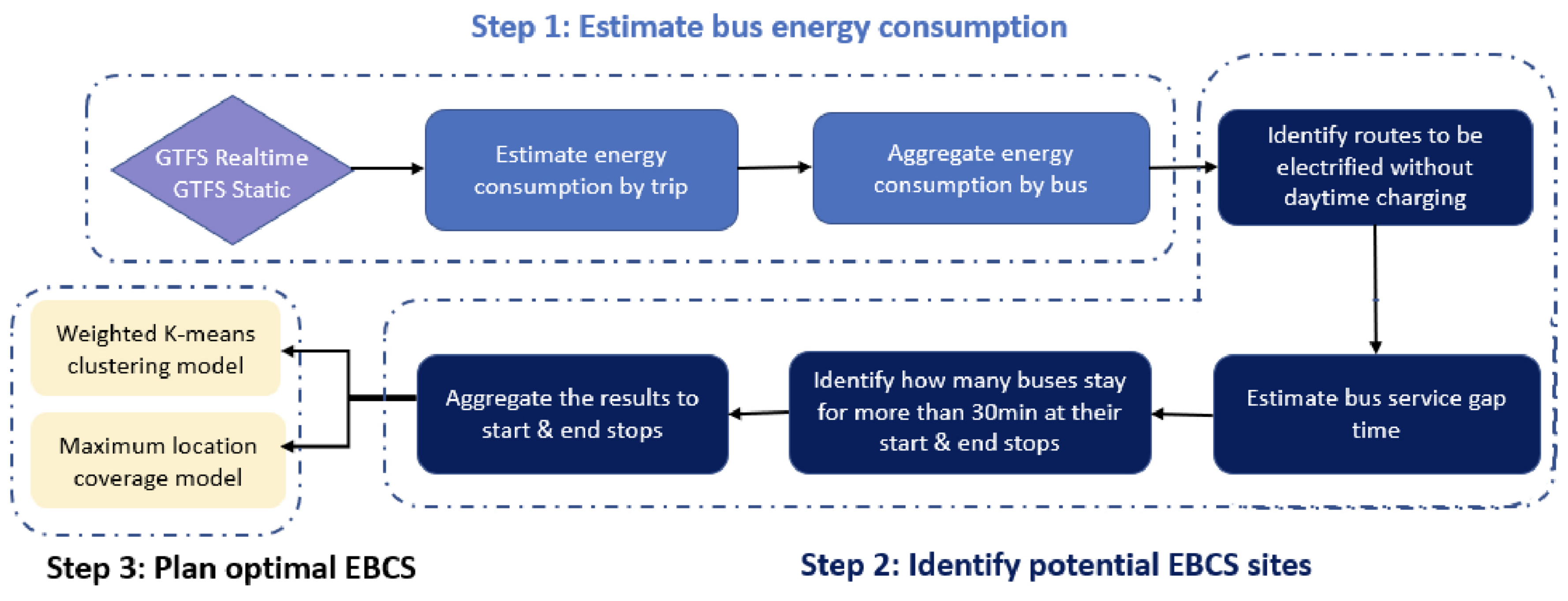



Figure 2. Analytical framework of bus electrification and EBCS siting

## Results

**Main finding from Step 1:** Route lines 126, 127 and 711 can run safely without daytime charging since their daily energy demand is lower than 120 Kwh.

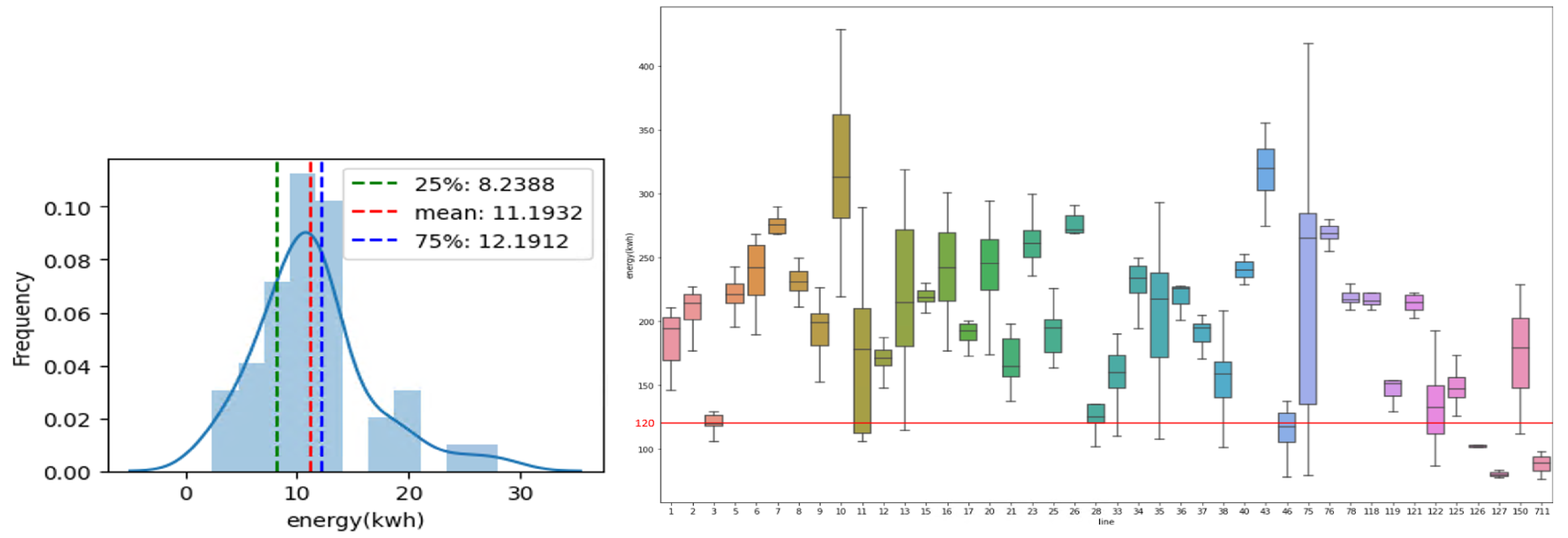
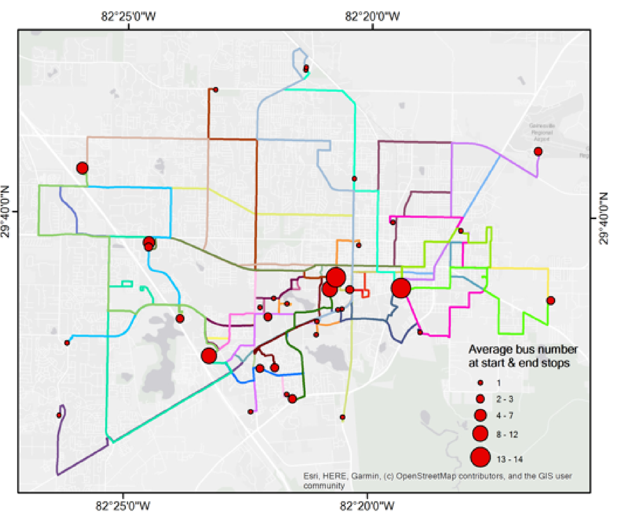



Figure 3. Bus energy consumption estimates (a). Average energy consumption of single trip on each route (b). Energy consumption of individual bus on each line



**Step 2:** Identity how many buses stay for more than 30min at their start end stops and aggregate the results to start & end stops

Figure 4. Average bus number staying at start end stop during service gap time

## Results Cont.

**Step 3:** based on the **location and size of charging demand aggregation**, two location siting models are applied and compared to **identify optimal EBCS**:

- **Weighted K-means clustering algorithm:** decide the location of EBCS based on the weighted average distance from terminals.
- **Maximum coverage location model:** the objective of MCLP is to maximize coverage accounting for demand while constrained by a fixed number of EBCS.
  **- Alternative 1:** Assume **all the terminals** are potential sites except for a few without any charging demand.
  **- Alternative 2:** Choose **all the 100 $m^2$ geographical grids** of the study area divided by GIS software. This is the **most effective** planning measurement in our studies.

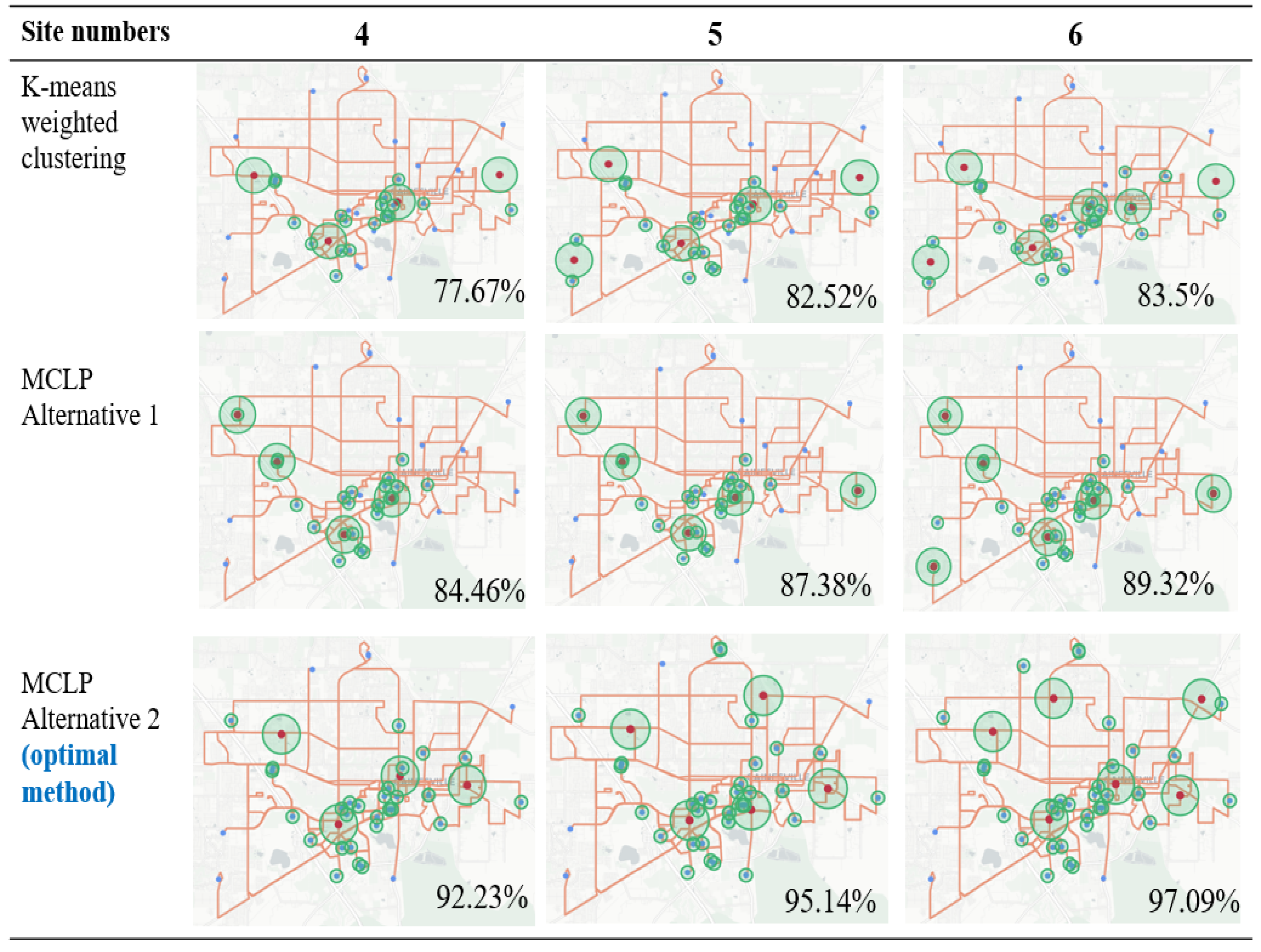



Figure 5. Optimal planning of EBCS with different models and the service range (%) of proposed EBCS

## Discussion

The framework has proven its effectiveness to the bus fleet in Gainesville. It can be also utilized in other study contexts, given its **generalizability of both dataset and methodology**.

This study assumes the schedule of e-buses fleet same as the current non-electrified bus fleet and ignores the charging capacity as a constraint in deciding EBCS location of EBCS. **Charging scheduling and charging capacity** should be considered in future studies to maximize the utilization of charging stations.