Fleet Electrification Feasibility Study
Demo Day Presentation
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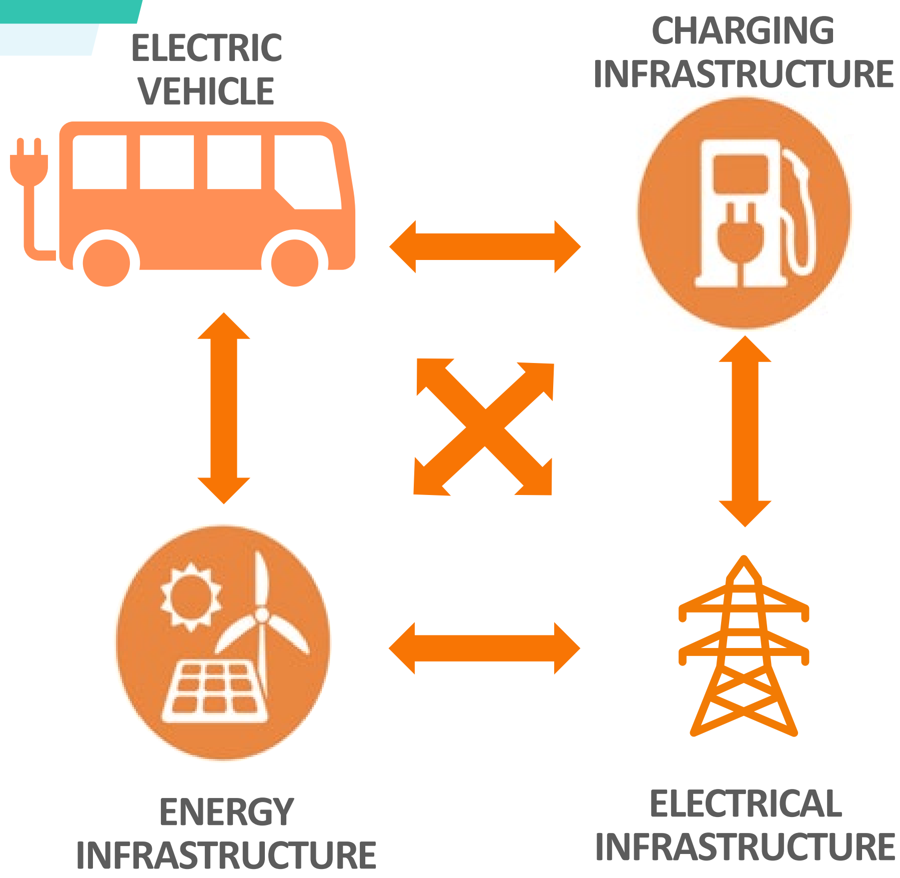
Industry Need

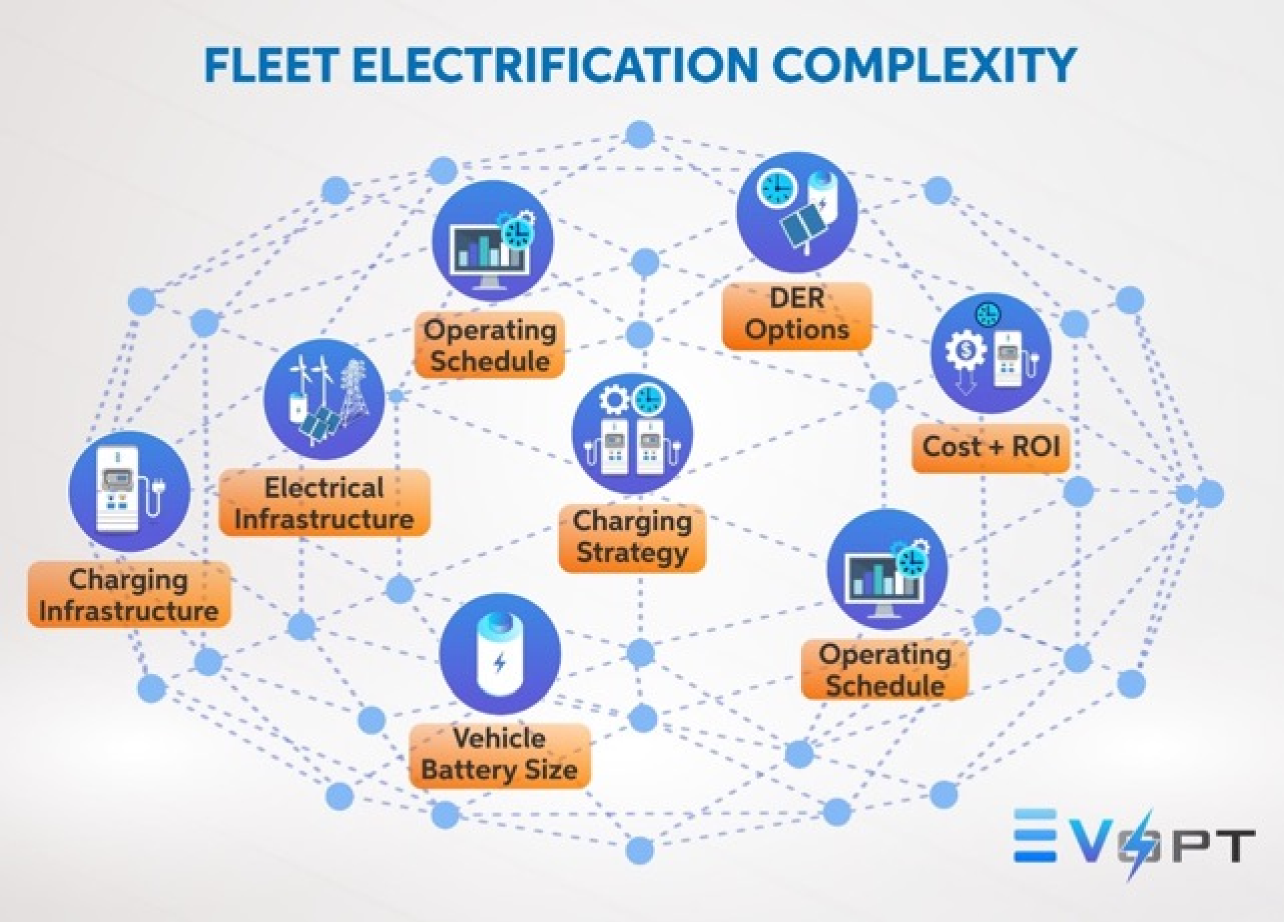
Fleet Electrification: Components and Interdependence



Fleets are now responsible for not just purchasing vehicles but building and operating the whole system. System components have extremely complex inter-dependencies.

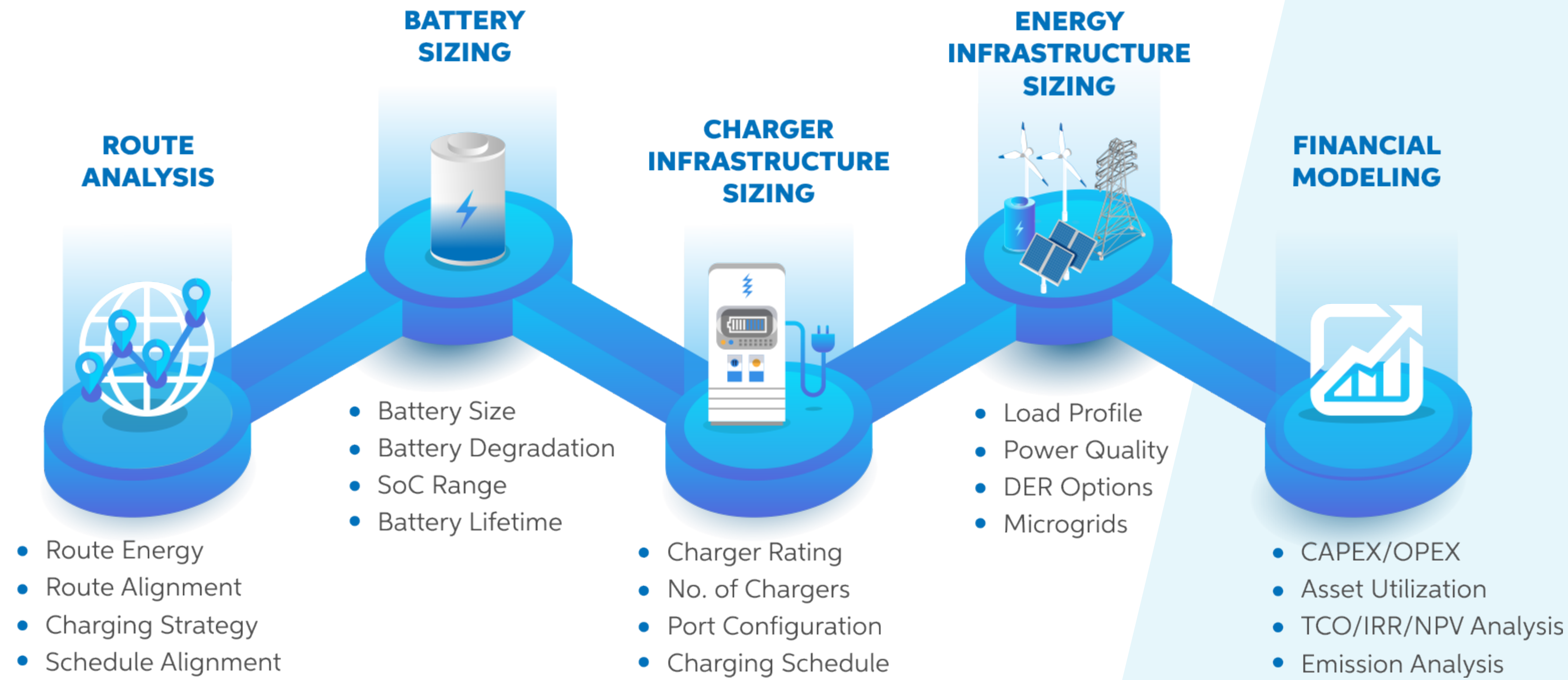
Opportunity

- Transitioning from traditional to electric mobility is a capital intensive process as electric vehicles are more expensive and need additional investments to develop the required charging infrastructure. These projects are also complicated by the several factors that influence their design, cost and performance.



Solution

EVOPT-Planner models the driving and charging process to determine the optimum size of the vehicle battery, charging infrastructure capacity and operational schedule to minimize capital and operational costs.



Project Scope at-a-Glance

Key Objective: Test technology services and supporting Ameren and their customers with the transition to EVs by potentially lower cost methods of providing fleet electric vehicle feasibility studies.

Key Deliverables:

1. **Feasibility Study**
2. Zero-Emission Fleet **Transition Plan**
3. Building a **Digital Twin** model of the electrical network at the depot.

Example:

DEPOT OF THE FUTURE

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Route Energy Analysis

Electric vehicles are extremely sensitive to how and where they are operated. Their performance and longevity depends on several factors.
EVOPT Planner takes the existing fossil-fuel based fleet operations data as input and simulates how an electric fleet will operate and perform under the same conditions.
First step in this project was to gather telematic information for the Hazelwood School Districts operations and perform detailed Route Energy Analysis, i.e. estimating the energy required on each route by and electric bus.

ROUTE ANALYSIS

- Route Energy
- Route Alignment
- Charging Strategy
- Schedule Alignment

1. Data Collection
    1. Route Details
    2. Operating Schedule
    3. Fuel consumption
2. Duty Cycle generation
3. Route Modeling, etc.

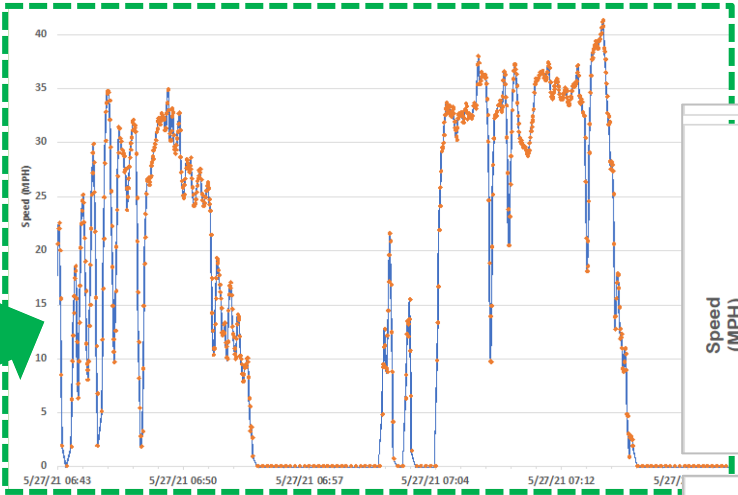
Route Energy Analysis

Duty Cycle generation

26 million data points analyzed

Raw Telematic Data as input

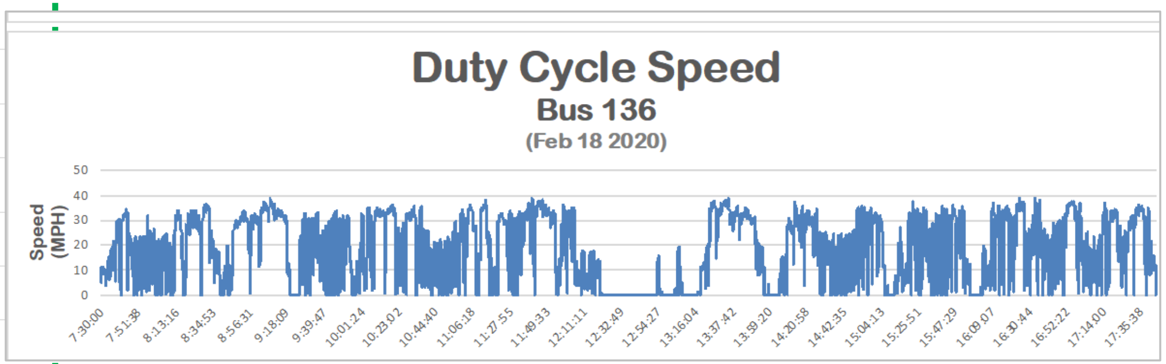
	A	B	C	D	E	F	G
1		Hazelwood School District 18th February Bus #136 data					
2							
3		Time	Latitude	Longitude	Elevation-Meters	Speed	Elevation-feet
4	0	7:30:00	38.8282879	-90.31282593	154.2111511	4.8	505.9421131
5	1	7:30:05	38.8282378	-90.31278488	153.3900757	8.4	503.2482959
6	2	7:30:11	38.82814577	-90.31281457	153.2816467	10.6	502.8925579
7	3	7:30:16	38.82805415	-90.3128752	153.0059204	11.2	501.9879439
8	4	7:30:22	38.82796792	-90.31291992	152.8607483	9.9	501.5116574
9	5	7:30:27	38.82787782	-90.31292707	152.8170013	9.9	501.3681307
10	6	7:30:32	38.82778215	-90.31291732	152.8142548	10.6	501.3591196
11	7	7:30:38	38.8276802	-90.31292122	152.9818878	10.8	501.9090968
12	8	7:30:43	38.827584	-90.3129348	153.0253601	10.7	502.0517225
13	9	7:30:49	38.82748935	-90.31296057	153.3471222	10.4	503.1073724
14	10	7:30:54	38.82741183	-90.31302387	153.9715729	9.8	505.1560952
15	11	7:30:59	38.8273743	-90.31312207	154.5604553	9.2	507.0881242
16	12	7:31:05	38.82737548	-90.31323153	154.7498627	9	507.7095394
17	13	7:31:10	38.82738922	-90.3133458	154.6118774	9.8	507.256832
18	14	7:31:16	38.8274151	-90.31346788	154.3856812	10.6	506.5147182
19	15	7:31:21	38.8274617	-90.31358233	154.4212799	10.9	506.631512
20	16	7:31:27	38.82752143	-90.31368258	154.6920929	10.5	507.5200061
21	17	7:31:32	38.82758727	-90.3137729	154.9476166	10.3	508.3583384
22	18	7:31:37	38.8276609	-90.31386302	155.2307434	10.7	509.2872322
23	19	7:31:43	38.82773213	-90.31394415	155.3749237	10.3	509.7602647
24	20	7:31:48	38.8278001	-90.31402397	155.5815735	9.8	510.4382496
25	21	7:31:54	38.8278649	-90.3141043	155.6277008	9.5	510.5895859
26	22	7:31:59	38.82792765	-90.31418127	155.9586029	9.3	511.6752228
27	23	7:32:04	38.8279901	-90.31425842	156.055954	9.3	511.9946161
28	24	7:32:10	38.82805442	-90.31433325	155.7488556	9.5	510.9870754
29	25	7:32:15	38.82811507	-90.31441095	155.5693054	9.4	510.398
30	26	7:32:21	38.82817575	-90.3144886	155.537674	9	510.2942222

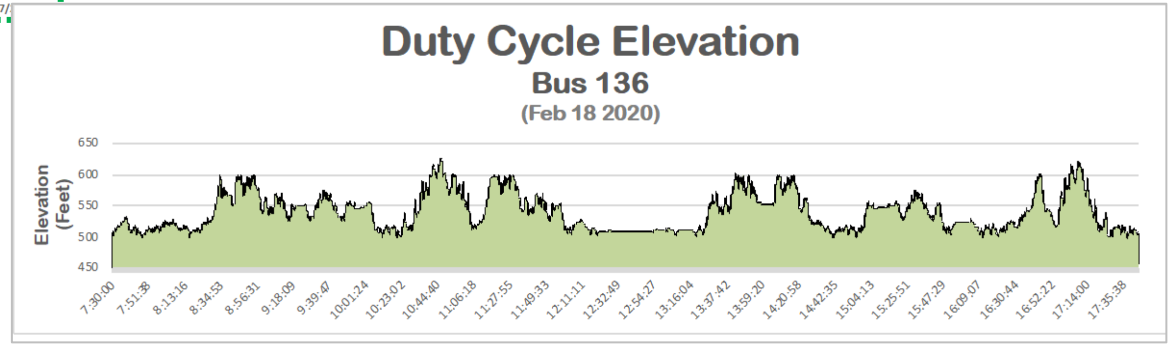


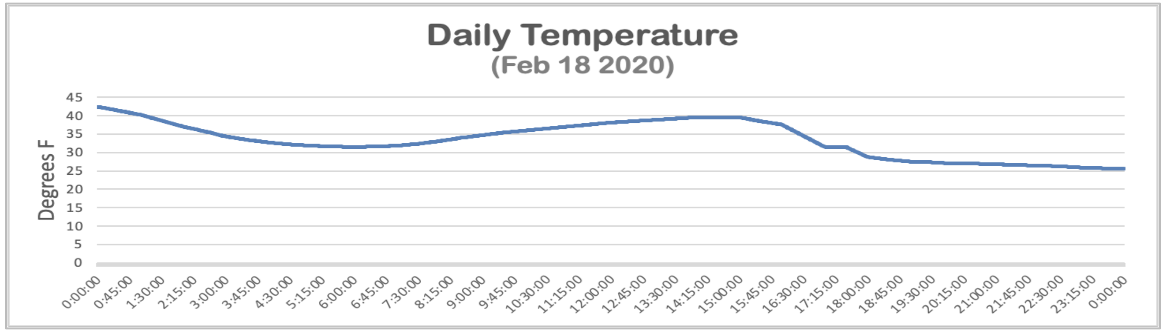
Speed vs Time trace for every bus for every day's operation. Detailed operations data helps in studying the operations.

Operation and performance of an electric bus is dependent on several factors including duty cycle, elevation, ambient temperature, passenger loading, etc.

EVOPT takes all these parameters as input and comes with optimized solution.







Telematic Operations Data and Analysis

Route details shown for one bus on one day.
More than 2800 bus-days analyzed

Each dot represents data being sent by the telematic system.
Each point includes information related to timestamp, location, speed, elevations, etc.

More than 26 million data points analyzed.

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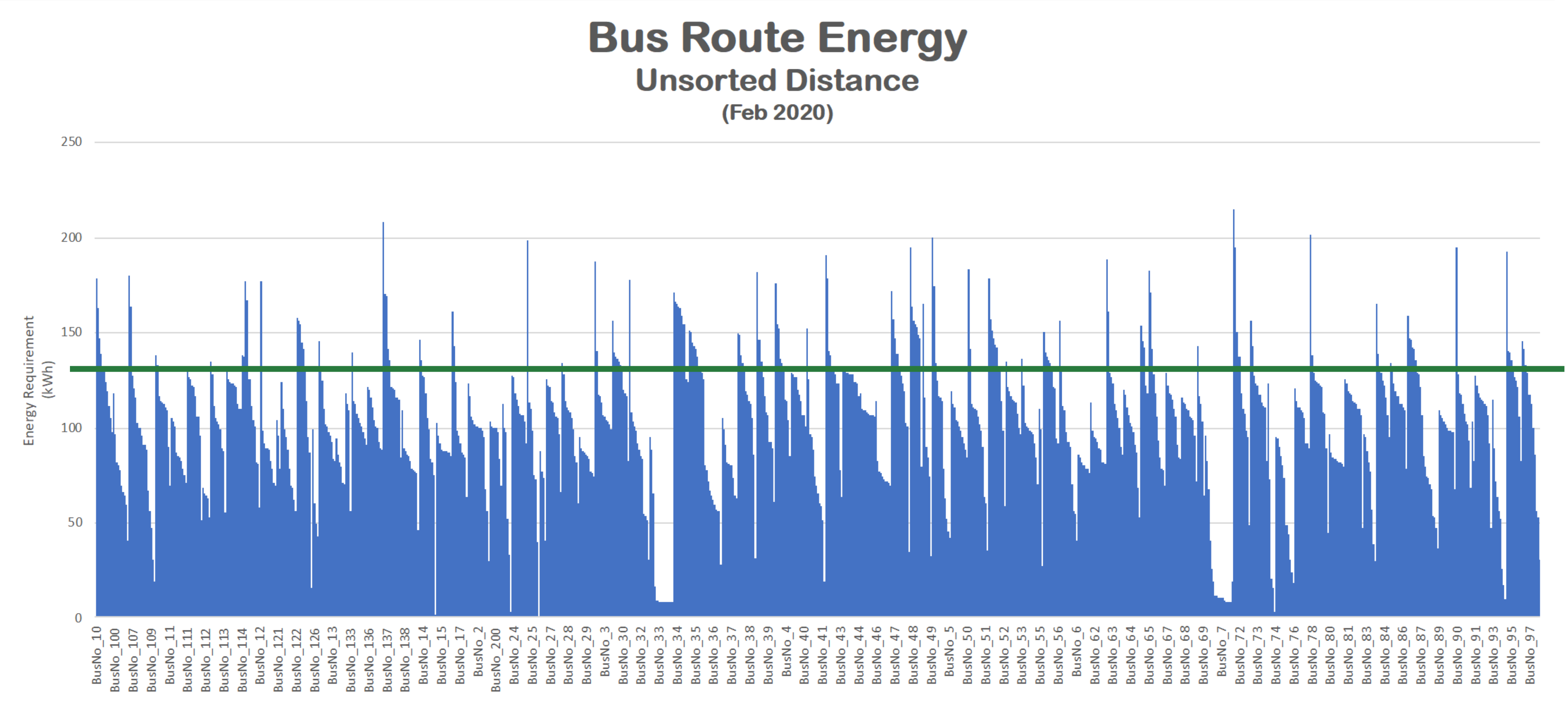
EPRI ELECTRIC POWER RESEARCH INSTITUTE

Route Energy Analysis

EVOPT PLANNER



Electric school buses available today have about ~130kWh Energy required.
Most of the routes, but not all, can be satisfied by Electric buses.

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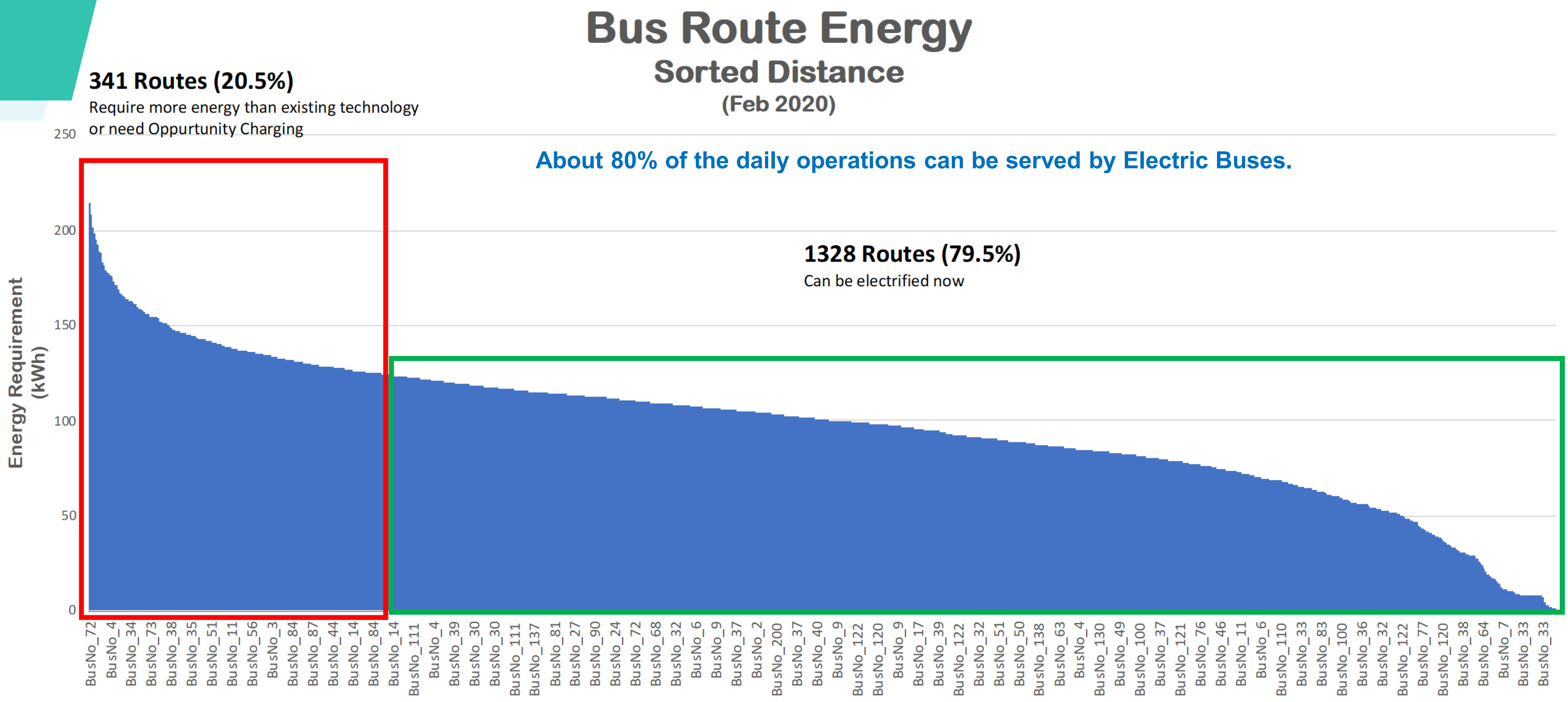
Route Energy Analysis



Route Energy Analysis

EVOPT PLANNER

Hazelwood Fleet Daily Energy Usage

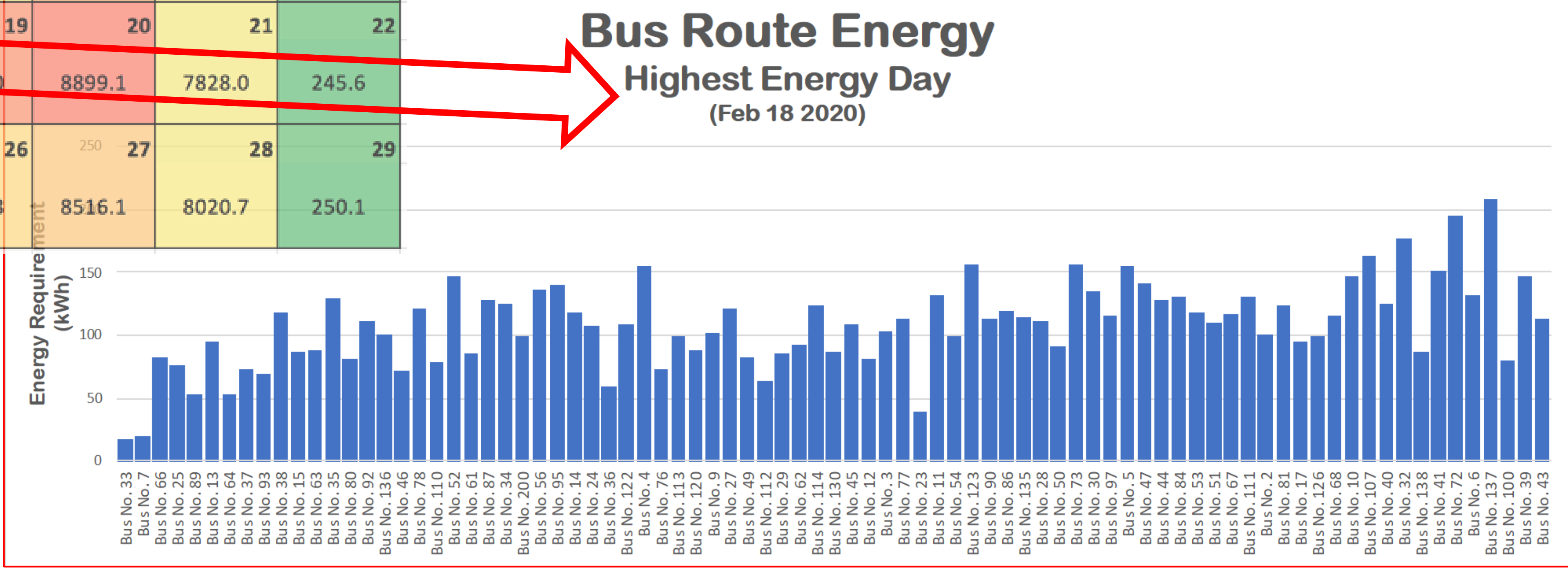
Febuary 2020

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
26	27	28	29	30	31	1 721.7
2	3 8876.7	4 8834.1	5 7051.4	6 8639.2	7 7803.1	8 302.1
9	10 8312.9	11 8868.6	12 8247.9	13 8627.7	14 8055.9	15 211.6
16	17 140.8	18 9042.8	19 8792.0	20 8899.1	21 7828.0	22 245.6
23 117.3	24 8347.7	25 8524.5	26 8421.8	27 8516.1	28 8020.7	29 250.1

Every route on every day is analyzed and based on that energy requirements are calculated.

Heat map showing energy requirements on a per day basis.

Worst-case (18th Feb) further analyzed in detail.



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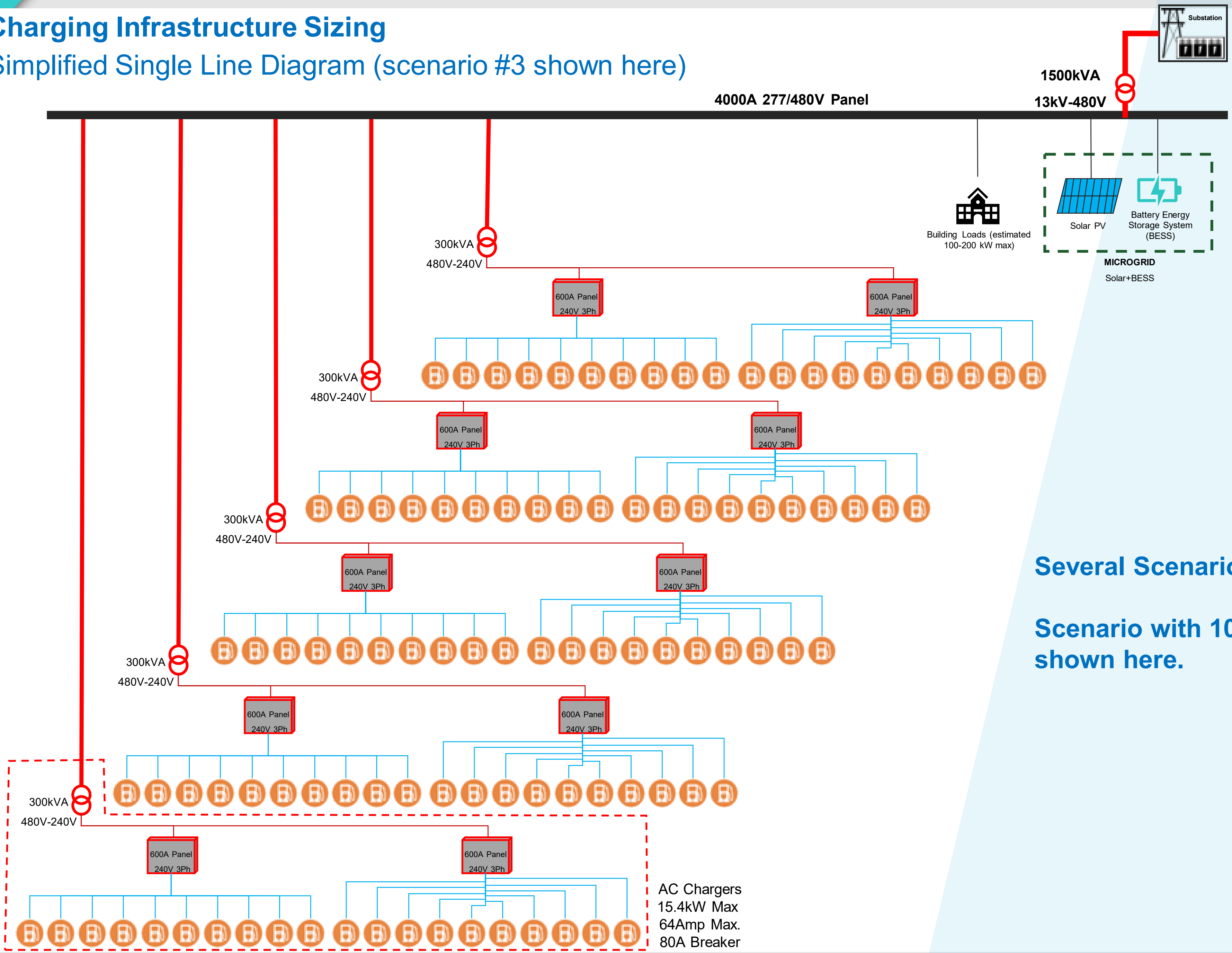
Charging Infrastructure Sizing

Simplified Single Line Diagram (scenario #3 shown here)

CHARGER INFRASTRUCTURE SIZING

- Charger Rating
- No. of Chargers
- Port Configuration
- Charging Schedule



Several Scenarios analyzed in detail.

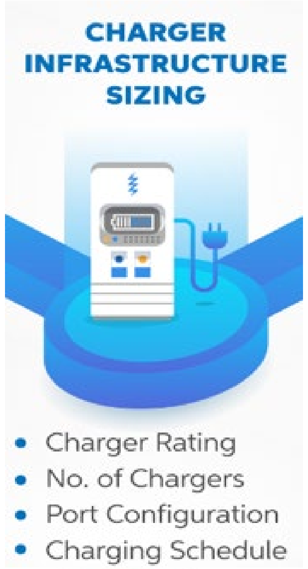
Scenario with 100x 15kW AC chargers shown here.

Charging Infrastructure Sizing

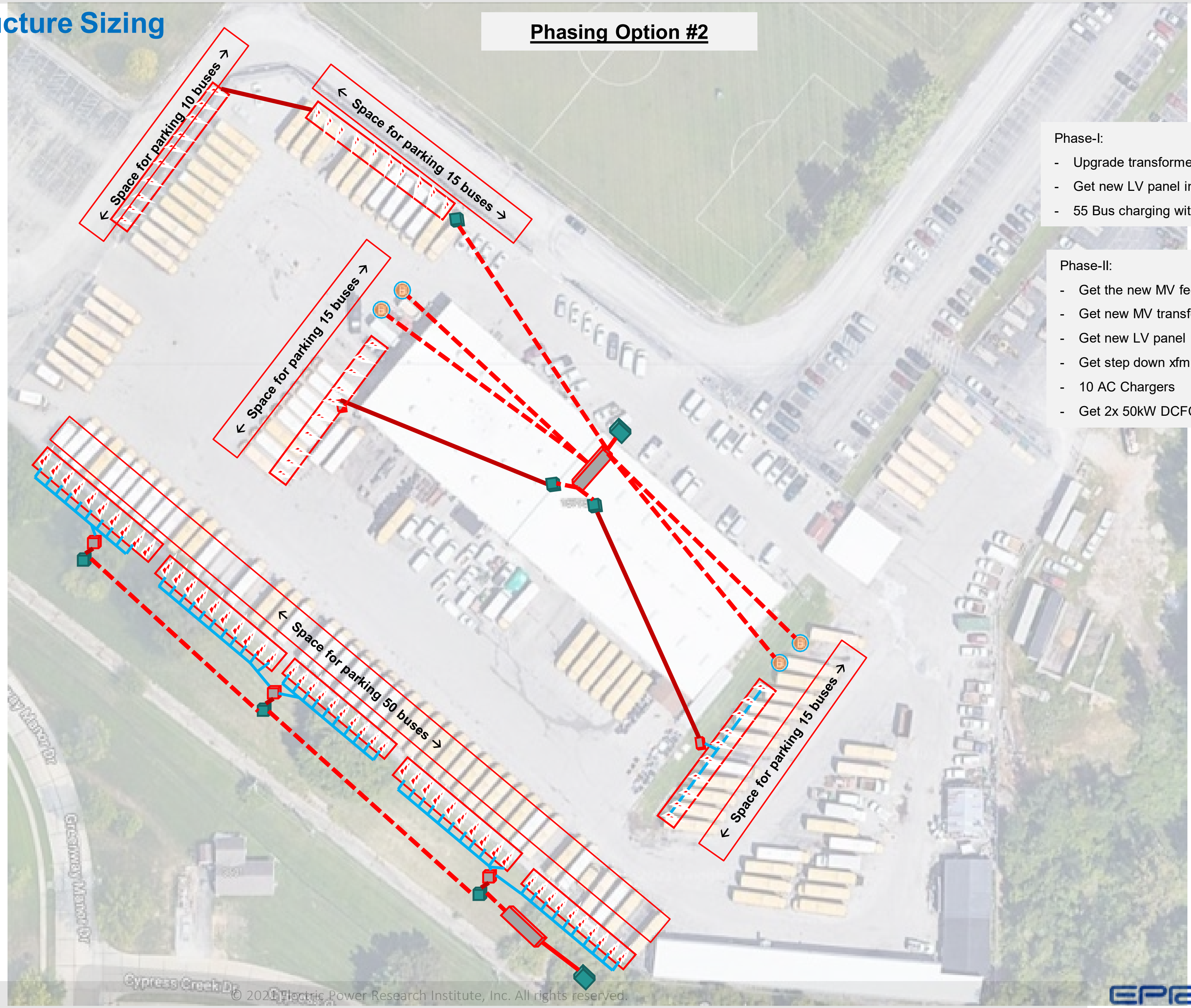
Map Layout

Map Layout and proposed phasing plan for infrastructure upgrade and charger installations.

Several options evaluated. One shown here.



Phasing Option #2



Phase-I:

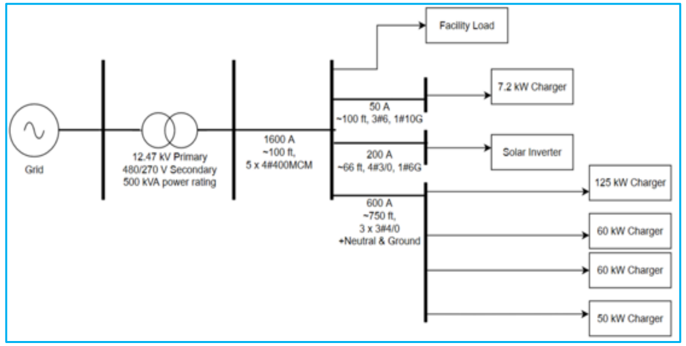
- Upgrade transformer with same feed
- Get new LV panel inside building
- 55 Bus charging with mix of Ac and DC

Phase-II:

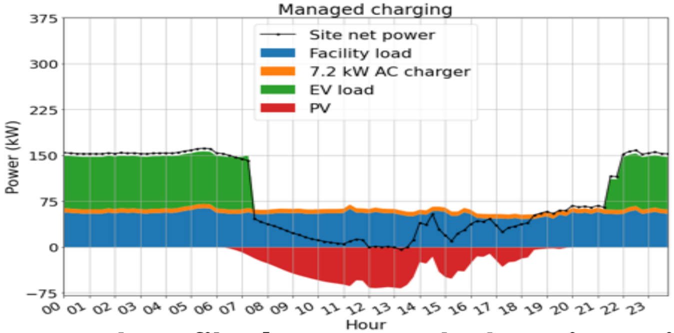
- Get the new MV feed to the South
- Get new MV transformer (check rating)
- Get new LV panel
- Get step down xfmr and 600A panel
- 10 AC Chargers
- Get 2x 50kW DCFC installed

Digital Twin of the Charging Depot

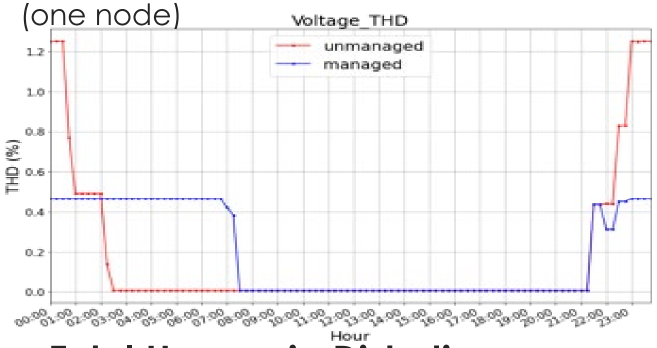
OpenDSS model and Digital Twin for power and energy analysis including Power Quality



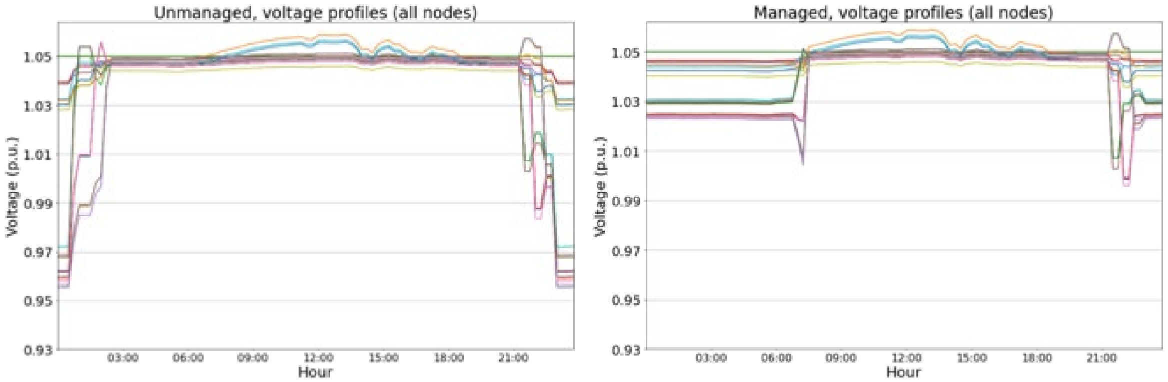
OpenDSS Modeling – Initial Topology
(section of the whole)



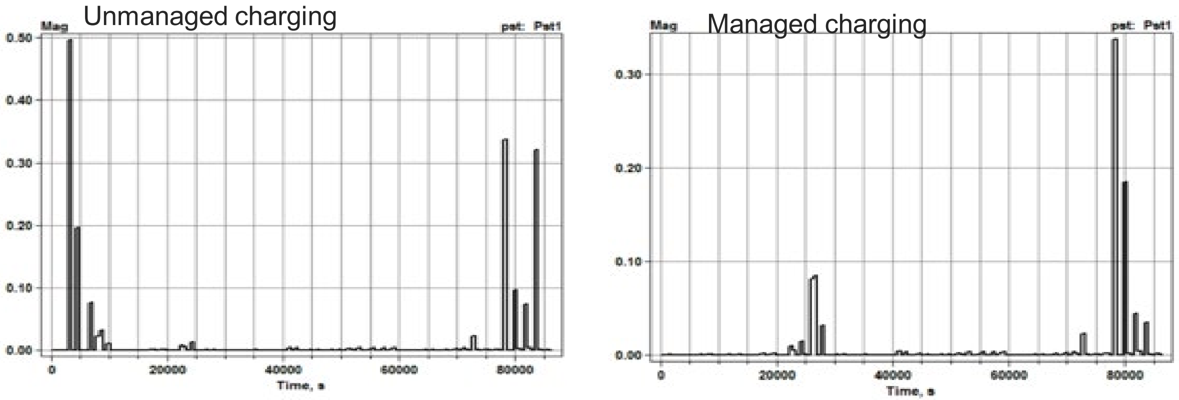
Load Profile (managed charging with DER)
(one node)



Total Harmonic Distortion



Nodes Voltages- Unmanaged v/s Managed



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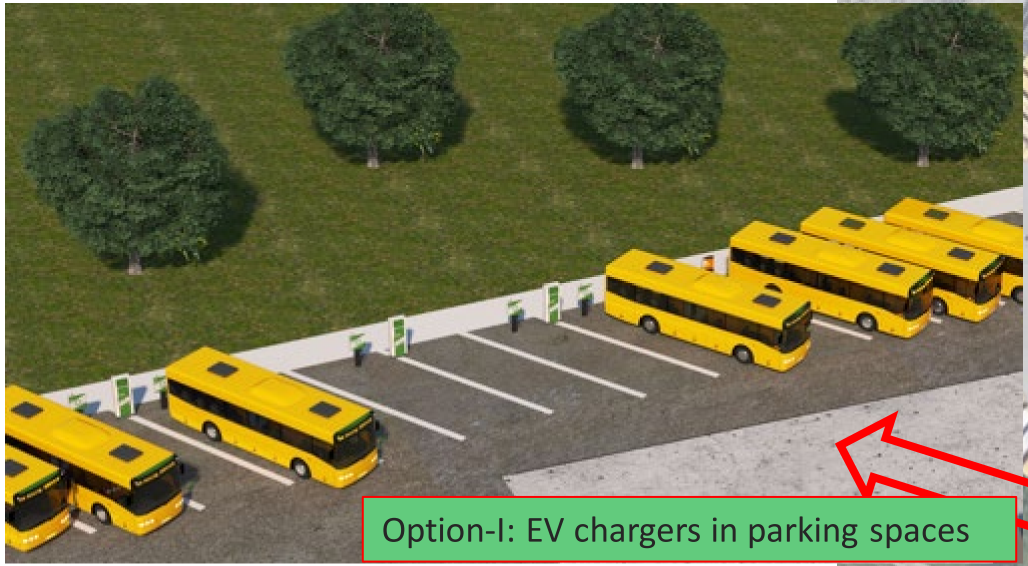
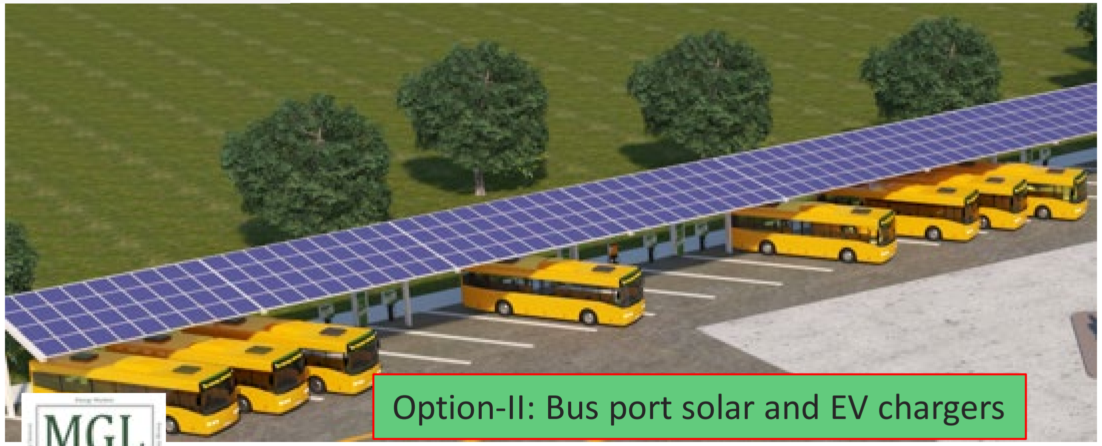
Energy Infrastructure Sizing

Solar PV based self generation

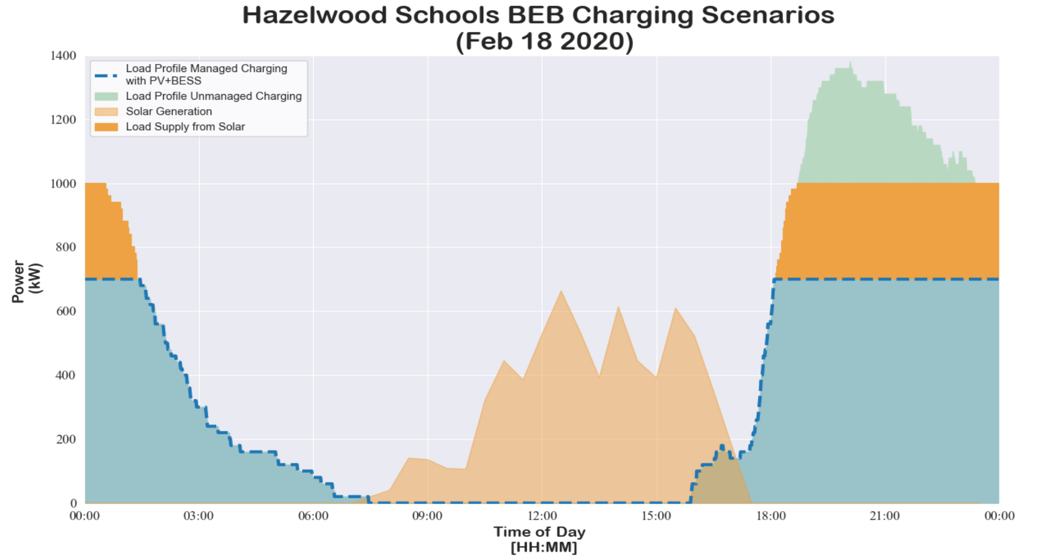


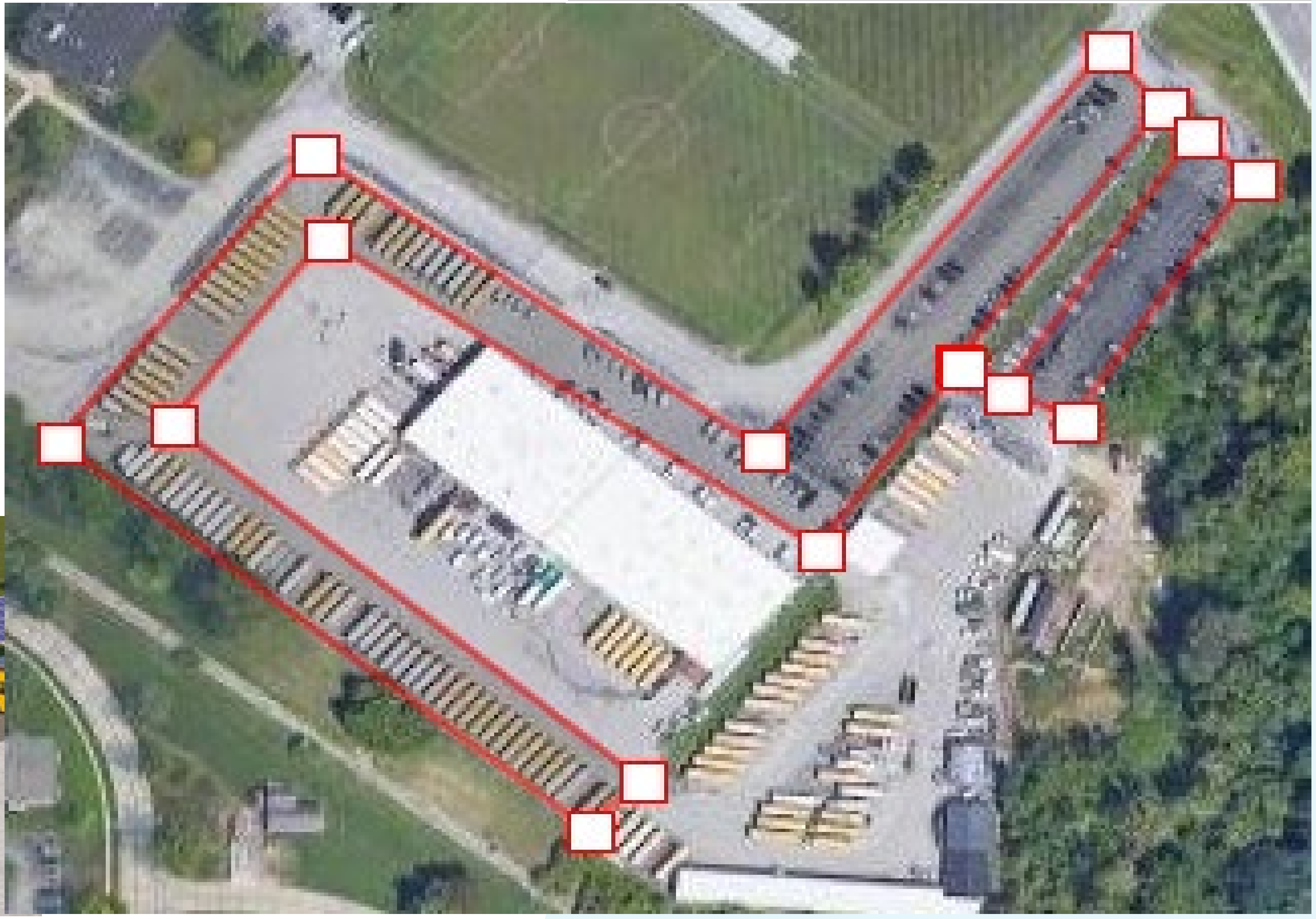


Energy Infrastructure Sizing

Busport and Carport Solar PV installation provides shade for the vehicles and generate energy in order to reduce operating cost and build resiliency.

System Capacity: 1571.8 kWdc (10479 m2)

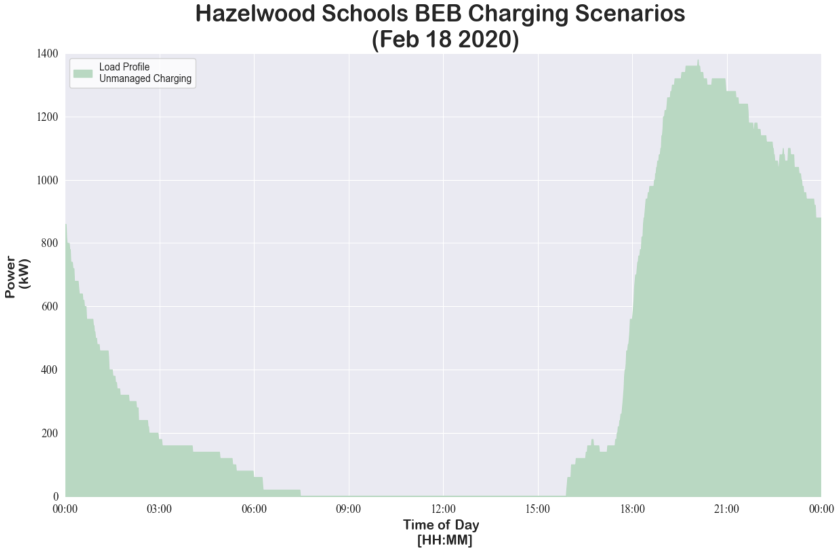




Load Profile and Financial Analysis

Load profile for unmanaged charging, managed charging and charging with onsite Solar PV based production

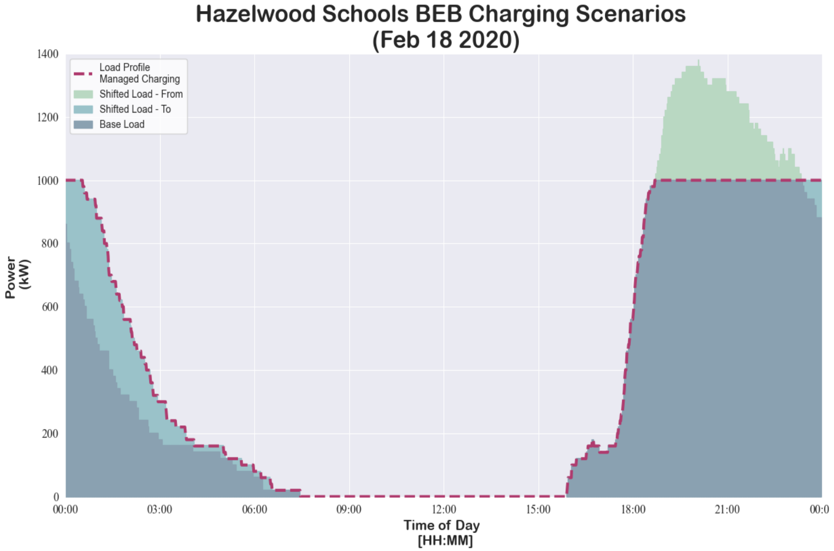
Unmanaged Charging



Peak Demand **1375kW**

100x Chargers

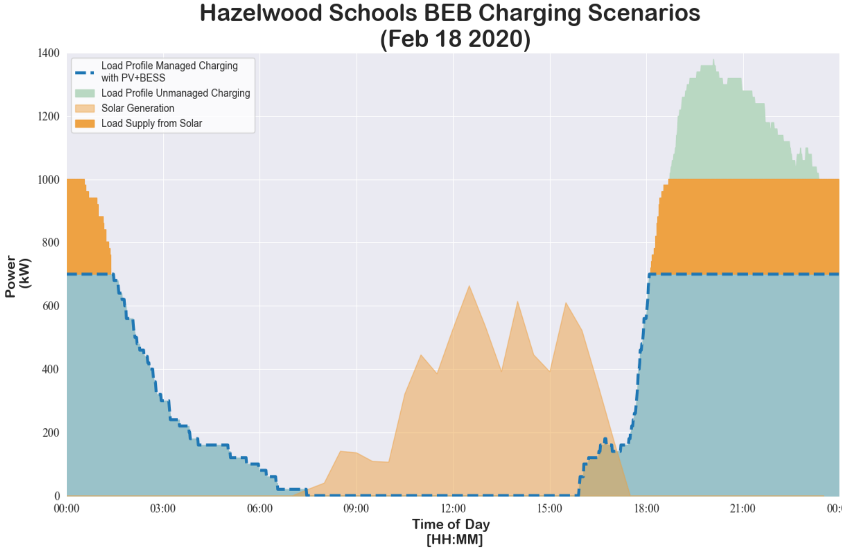
Managed Charging



Peak Demand **1000kW**

100x Chargers

Managed Charging (with Solar PV and Battery Storage)



Peak Demand **700kW**

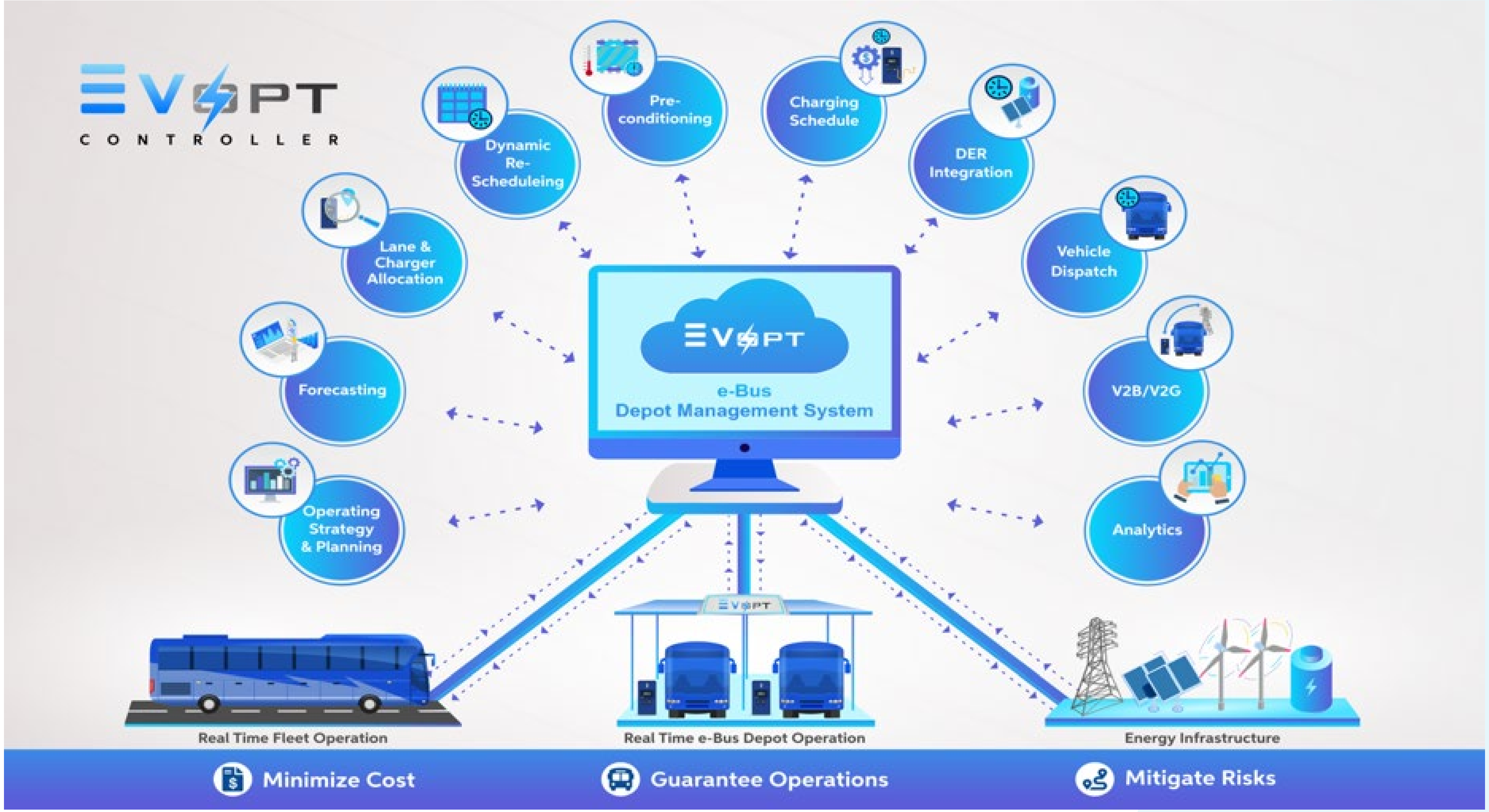
100x Chargers

1.5MW Solar PV + 1MWh BESS

~$6M Capex for PV+BESS

Path Forward and Next Steps

Implementation of Depot Management System in a real-world scenario operating an Electric Vehicle Fleet.



Our Team

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