Zero Emission Vehicle Transition Plan & Regional Support Study

CCRTA ZEV Transition Analysis & Key Takeaways

05/10/2023

HATCH

Agenda

- Operations Analysis
- Estimated Procurement Timelines
  - Vehicles
  - Infrastructure
- Life Cycle Cost Analysis
- Market Options
- Community Considerations
- Key Takeaways & Next Steps
- Questions

Operations Analysis

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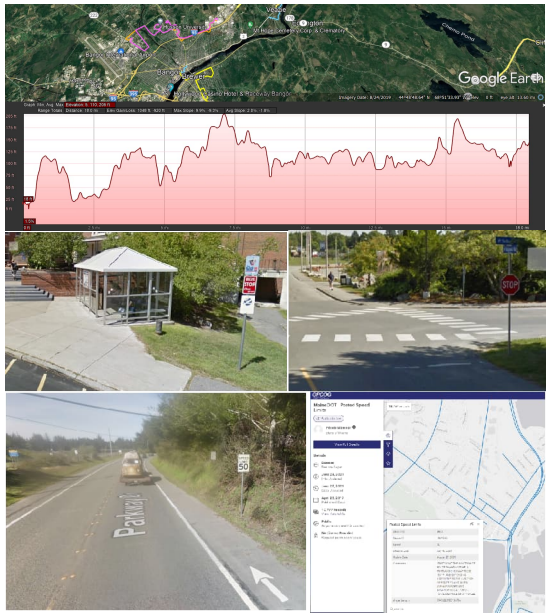
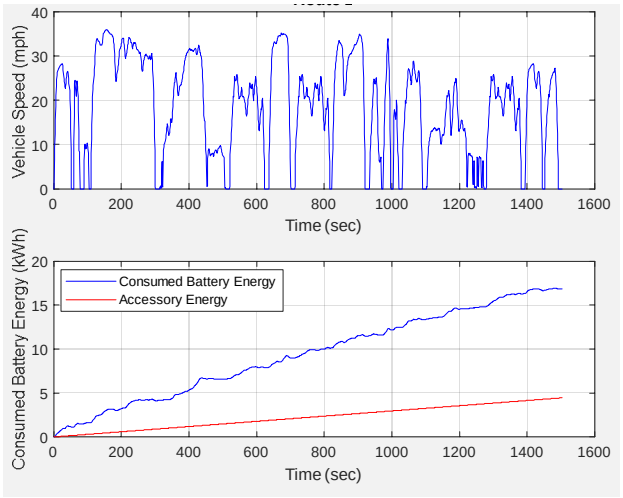
Operations Modeling: The Fixed Routes

Route Configuration



Route Geography and Traffic Patterns



Energy Consumption per Trip

Data Processing & Drive Cycle Generation

Drive Cycle Simulation & Energy Calculation

Operations Modeling: The Fixed-Route Vehicles

Transit Bus

Nominal Energy: 492 kWh

–20% for aging

–20% margin + battery health

Usable Energy: 315 kWh

Usable Range: 156 mi

Cutaway

Nominal Energy: 157 kWh

–20% for aging

–20% margin + battery health

Usable Energy: 100 kWh

Usable Range: 79 mi

Trolley

Nominal Energy: 127 kWh

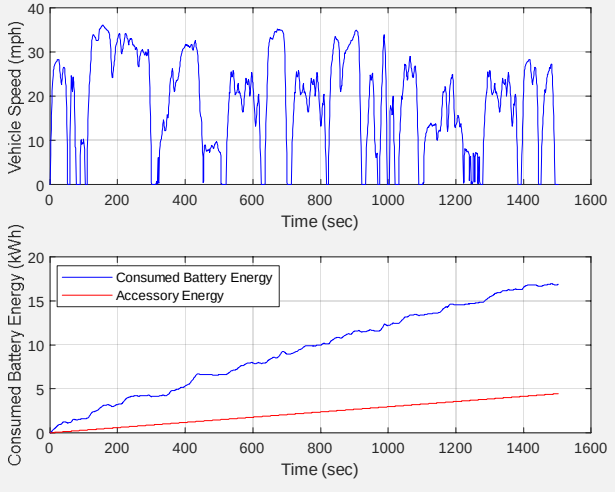
–20% for aging

–20% margin + battery health

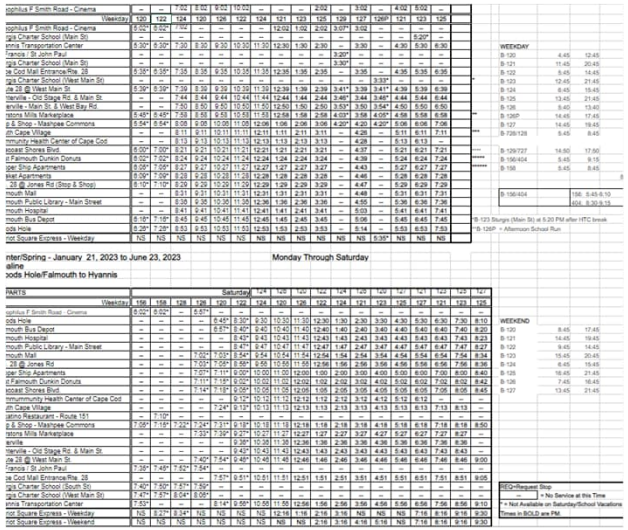
Usable Energy: 81 kWh

Usable Range: 54 mi

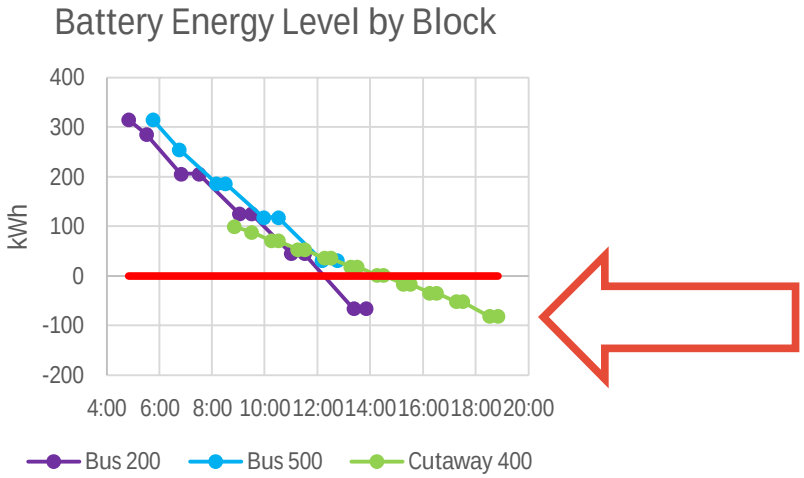
Operations Modeling:
The Fixed-Route Service Patterns



Energy Consumption per Trip



Operating Blocks



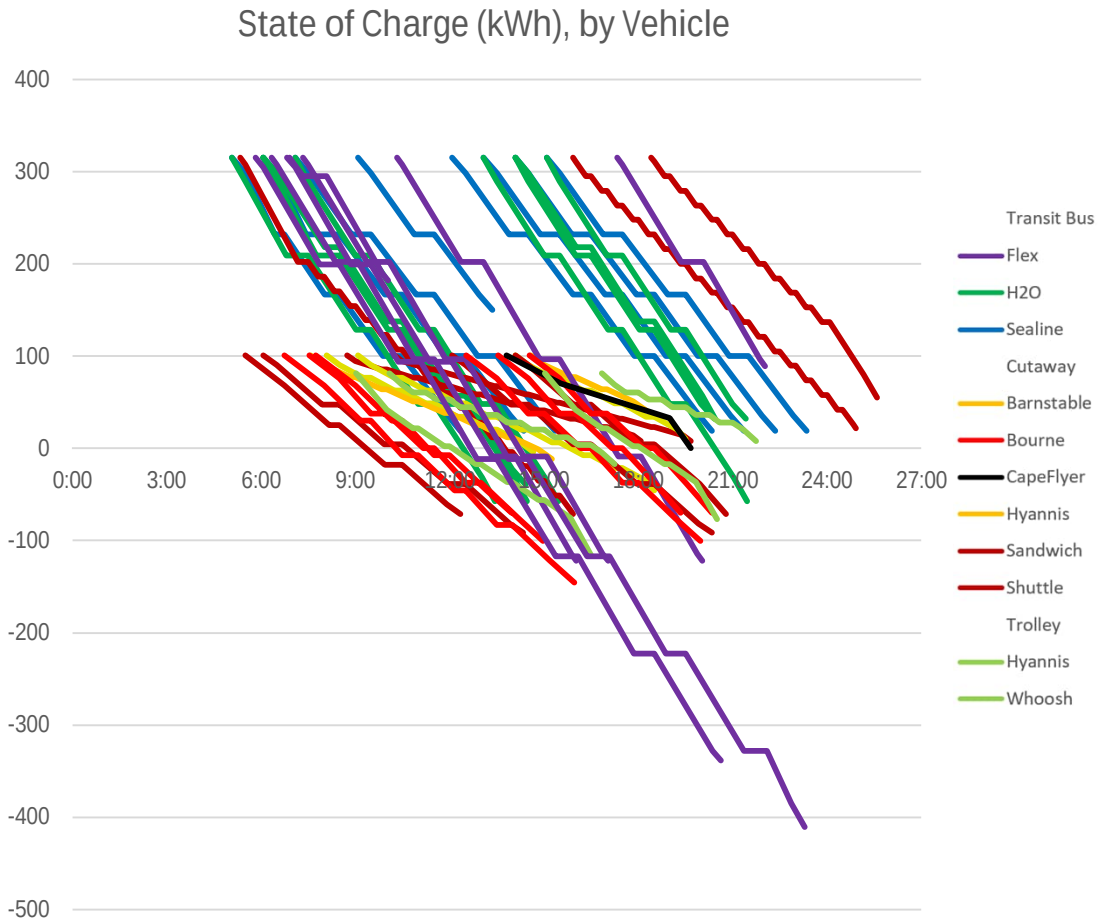
Energy Consumption per Day

Energy per trip, over all trips…

…yields energy needed per day

Operations Modeling: The Fixed Routes

Existing Operations



EV Operations Strategies:

- Shorter blocks (more vehicles)
- On-route charging
- ~~Use of diesel or hybrid vehicles~~

Assumption: no changes to passenger-facing schedules

Operations Modeling: The Fixed Routes

- Key Hubs:

Operations Modeling: Demand-Response

tion	City	Est	Sched	ReqL	Slack	Act.Arr	Act.Dep	Distance	Travel	Vehicle	FareAmou	FareToColl	FareCollec	Odom(Mil	Driver Nar	Total Cc
TH DE	South Den	7:11	7:15			7:11	7:11			429	0	0	0	197245.1	Davies Gri	
BUCK	WEST YAR	7:35	7:14		1	7:34	7:35	6.92	14	429	3	3	0	197251.9	Davies Gri	
VILDV	WEST YAR	7:41	7:13		0	7:40	7:41	1.85	3	429	3	3	0	197253.1	Davies Gri	
UART	SOUTH YA	7:50	7:20		0	7:50	7:50	3.06	6	429	3	3	0	197255	Davies Gri	
VITCH	SOUTH YA	7:54	7:23		0	7:53	7:54	0.92	1	429	3	3	0	197255.6	Davies Gri	
OLEW	SOUTH YA	8:00	7:28		0	8:00	8:00	1.1	2	429	3	3	0	197256.5	Davies Gri	
ONEY	SOUTH YA	8:07	7:34		0	8:07	8:07	2.31	4	429	3	3	0	197258.5	Davies Gri	
EER N	HARWICH	8:30	8:00		0	8:29	8:30	10.9	23	429	3	3	0	197269	Davies Gri	
house	HARWICH	8:35		8:45		8:35	8:35	1.33	2	429	3	3	0	197270.5	Davies Gri	
house	HARWICH	8:35		8:45		8:35	8:35		0	429	3	3	0	197270.5	Davies Gri	
house	HARWICH	8:35		8:45		8:35	8:35		0	429	3	3	0	197270.5	Davies Gri	
house	HARWICH	8:35		8:45		8:35	8:35		0	429	3	3	0	197270.5	Davies Gri	
house	HARWICH	8:35		8:45		8:35	8:35		0	429	3	3	0	197270.5	Davies Gri	
house	HARWICH	8:35		8:45		8:35	8:35		0	429	3	3	0	197270.5	Davies Gri	
house	HARWICH	8:35		8:45		8:35	8:35		0	429	3	3	0	197270.5	Davies Gri	
and S	ORLEANS	9:12	9:10		0	9:12	9:12	7.58	15	429	3	3	0	197277.5	Davies Gri	
AIN S	ORLEANS	9:19	9:15		2	9:17	9:19	1.13	2	429	1.5	1.5	0	197278.5	Davies Gri	
halm	WEST YAR	9:47		10:45		9:46	9:47	17.82	38	429	1.5	1.5	0	197295.4	Davies Gri	
Cod	HYANNIS	9:56		11:00		9:56	9:56	2.99	5	429	3	3	0	197298.2	Davies Gri	
enius	YARMOUT	11:15	11:00		15	11:00	11:15	3.36	6	429	1.5	1.5	0	197304.6	Davies Gri	
MCGU	HARWICH	11:37				11:37	11:37	14.83	33	429	1.5	1.5	0	197318	Davies Gri	
ry - B	BREWSTER	12:02	12:00		0	12:01	12:02	6.09	12	429	1.5	1.5	0	197323.6	Davies Gri	
ANGL	BREWSTER	12:10				12:10	12:10	2.86	5	429	1.5	1.5	0	197325.5	Davies Gri	
LEAS	HARWICH	12:37	12:30		4	12:32	12:37	4.46	11	429	1.5	1.5	0	197331	Davies Gri	
or Cer	HARWICH	12:40		13:00		12:39	12:40	0.61	1	429	1.5	1.5	0	197331.6	Davies Gri	
and S	HARWICH	13:04	13:00		1	13:02	13:04	4.04	8	429	1.5	1.5	0	197334.6	Davies Gri	
FRED	BREWSTER	13:14				13:14	13:14	5.77	12	429	1.5	1.5	0	197340.2	Davies Gri	
house	HARWICH	15:01	14:55		0	15:00	15:01	4.96	10	429	3	3	0	197346.7	Davies Gri	
house	HARWICH	15:02	14:55		0	15:02	15:02		0	429	3	3	0	197346.7	Davies Gri	
house	HARWICH	15:02	14:55			15:00	15:00		0	429	3	3	0	197346.7	Davies Gri	
house	HARWICH	15:02	14:55		0	15:02	15:02		0	429	3	3	0	197346.7	Davies Gri	
house	HARWICH	15:02	14:55		0	15:02	15:02		0	429	3	3	0	197346.7	Davies Gri	
house	HARWICH	15:02	14:55			15:01	15:01		0	429	3	3	0	197346.7	Davies Gri	
house	HARWICH	15:02	14:55			14:57	14:58		0	429	3	3	0	197346.7	Davies Gri	
EER N	HARWICH	15:09				15:09	15:09	1.33	2	429	3	3	0	197348.2	Davies Gri	
OLEW	SOUTH YA	15:33				15:33	15:33	10.35	22	429	3	3	0	197359.1	Davies Gri	
ONEY	SOUTH YA	15:42				15:42	15:42	2.31	4	429	3	3	0	197362	Davies Gri	
APTA	SOUTH YA	15:51				15:51	15:51	3.41	6	429	3	3	0	197365.3	Davies Gri	
UART	SOUTH YA	15:54				15:54	15:54	0.53	1	429	3	3	0	197365.7	Davies Gri	
VILDV	WEST YAR	16:02				16:02	16:02	3.06	6	429	3	3	0	197367.6	Davies Gri	
BUCK	WEST YAR	16:08				16:07	16:08	1.88	3	429	3	3	0	197369.5	Davies Gri	
		16:32			9			7.06	14	429	0	0	0		Davies Gri	
TH DE	South Den	16:32	17:00		27	16:32	16:32	0.14	0	429	0	0	0	197375.5	Davies Gri	

Cutaway Vehicle

Nominal Energy: 157 kWh

–20% for aging

–20% margin + battery health

Usable Energy: 100 kWh

Usable Range: 92 mi

Typical Routes

Miles/day: 87, 120, 130, 175

Midday breaks: on some routes

EV Operations Strategies:

-More (shorter) runs

-Lunchtime charging

-Some ICE vehicles retained

Operations Modeling: Demand-Response Sample Runs

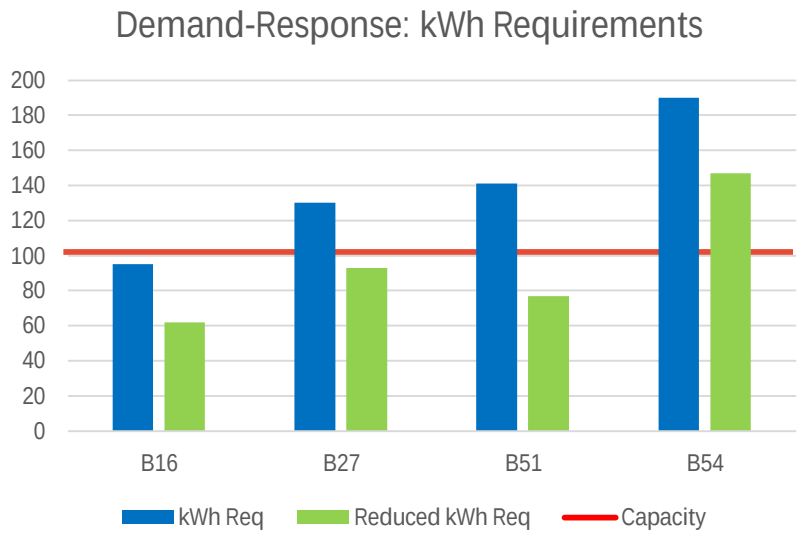
Vehicle	Miles	kWh Req	Lunch Break Duration
B16	87	95	49 min
B27	120	130	55 min
B51	130	141	96 min
B54	175	190	64 min

Assumptions:

- 50% of lunch break time can be used for charging at nearby charging station
- DC fast charging (80 kW)
- Representative sample

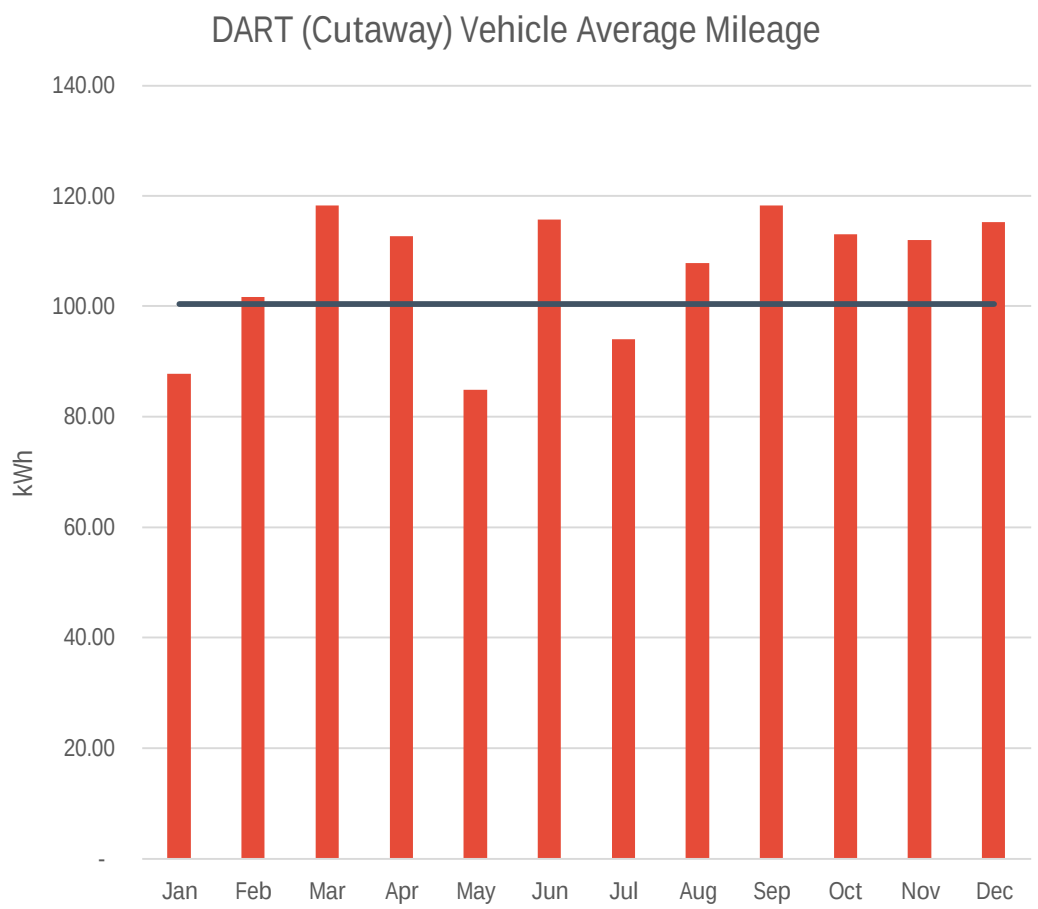
Operations Modeling: Demand-Response Sample Runs

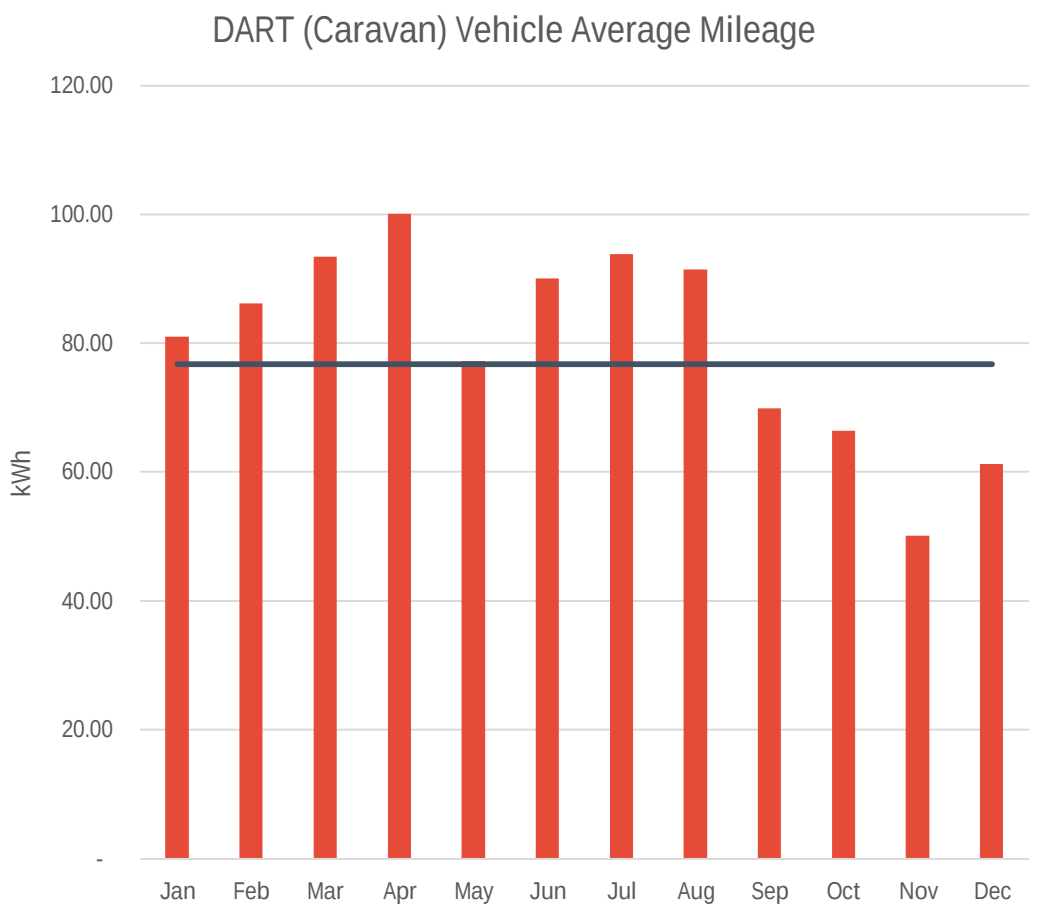
Vehicle	Miles	kWh Req	Lunch Break Duration	kWh Gained During Lunch	Reduced kWh Req
B16	87	95	49 min	33	62
B27	120	130	55 min	37	93
B51	130	141	96 min	64	77
B54	175	190	64 min	43	147



Operations Modeling: Demand-Response (Fleet-Wide)

Peak Service Vehicles
- Cutaway: 36
- Caravans: 6





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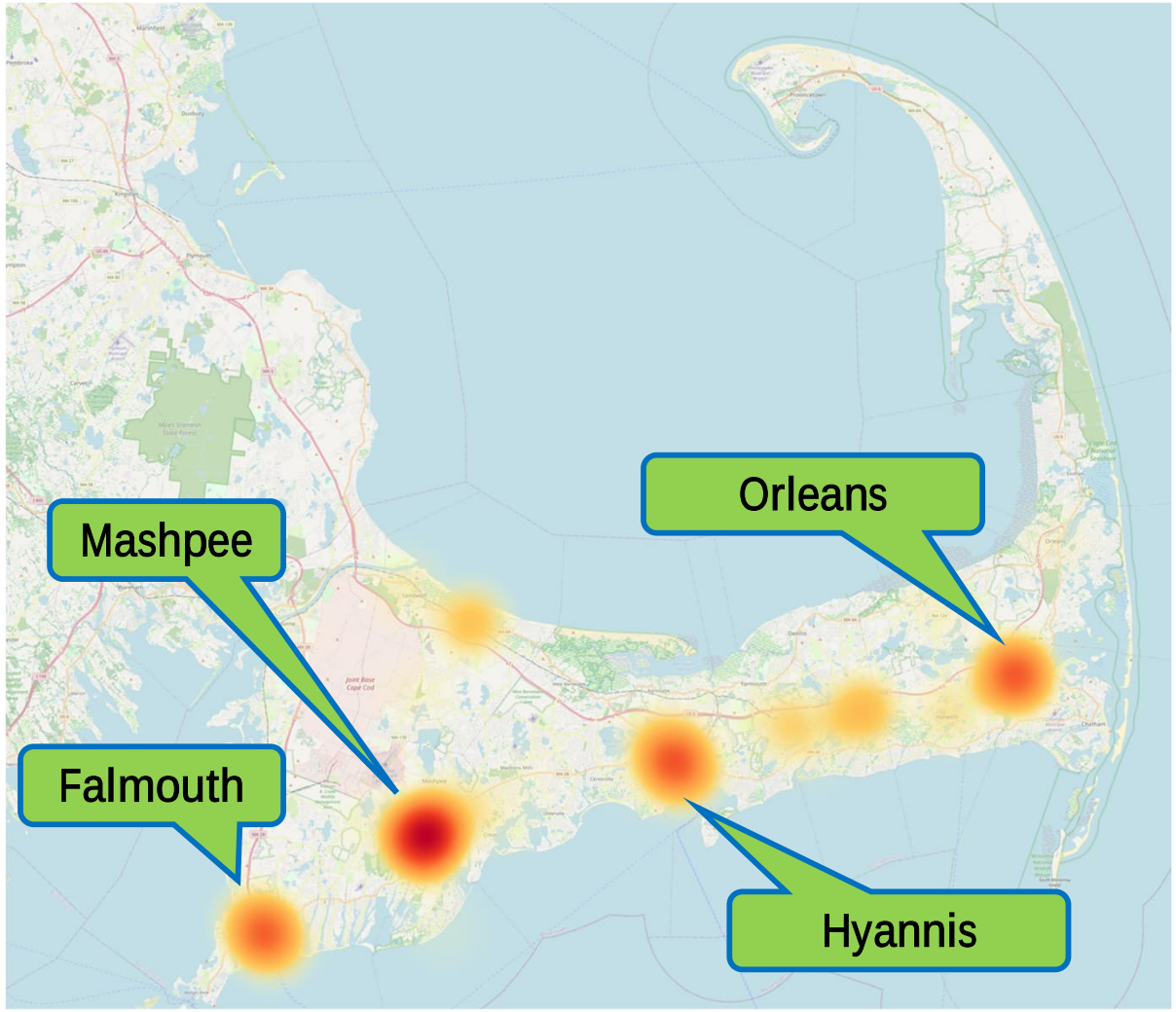
On-Route Charging

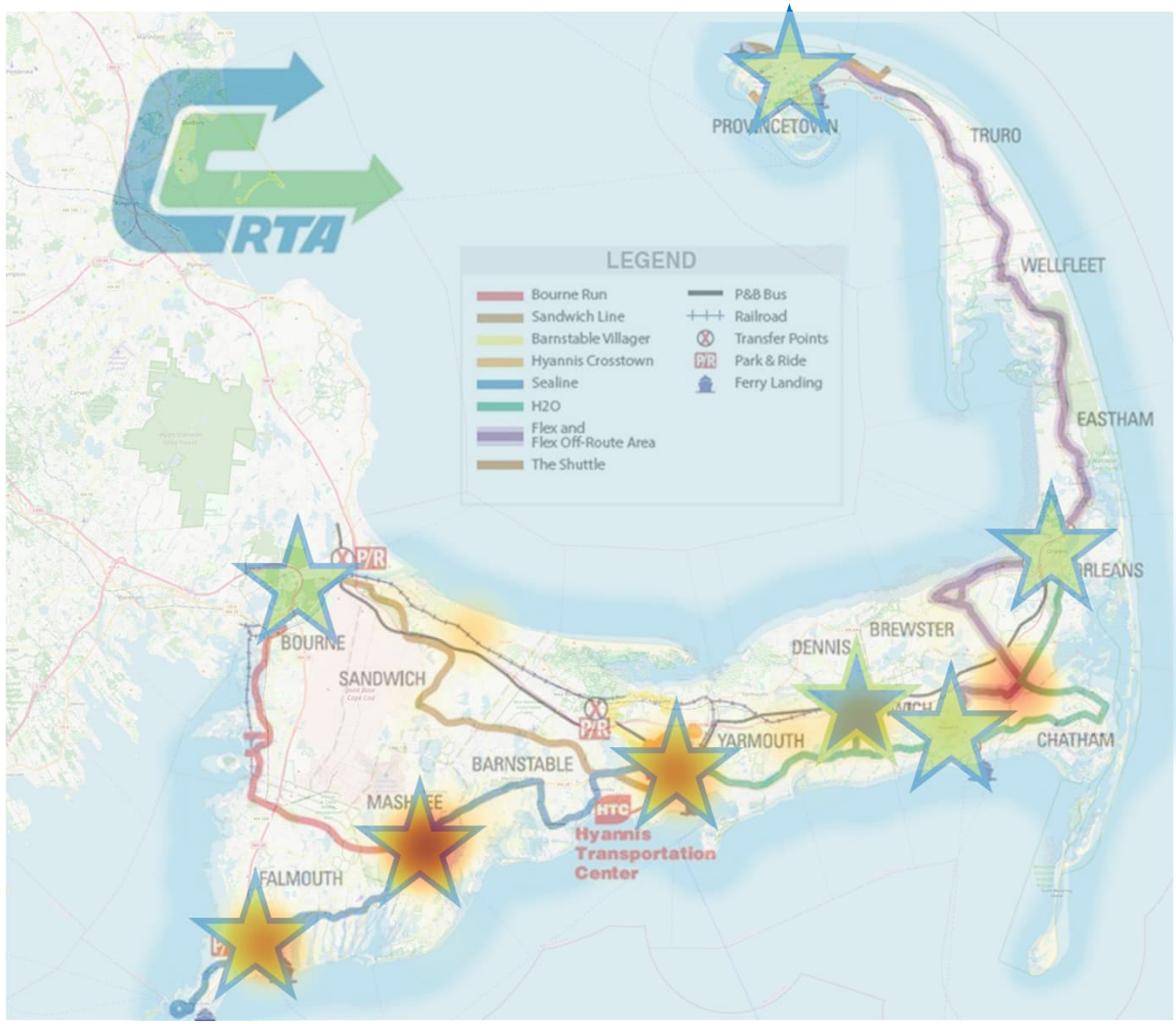
- Key Hubs:



On-Route Charging

- Key Hubs:

On-Route Charging



On-Route Charging

Use of Third-Party Charging Station

On-Route Charging Station

Depot

On-Route Charging: Assumed Locations

Mashpee

Use of Third-Party Charging Station

On-Route Charging Station

Route Terminal

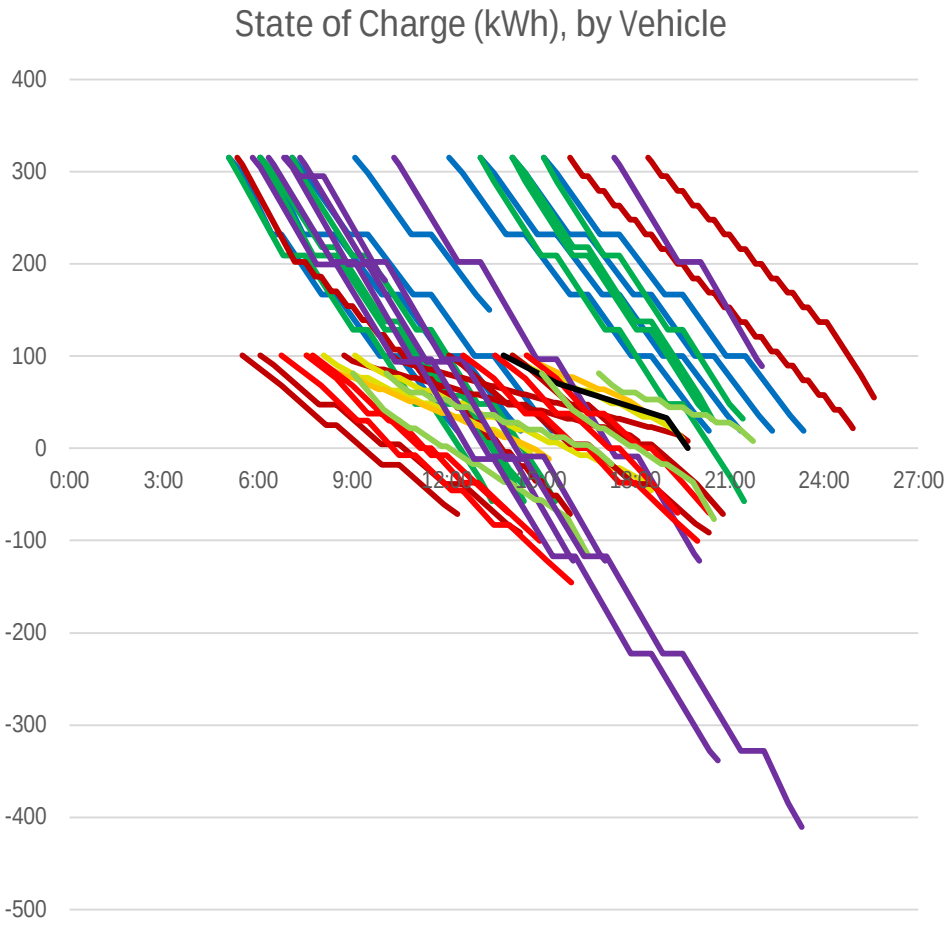
Provincetown (Midday & Overnight)

Falmouth – Palmer Parking Lot (Midday)

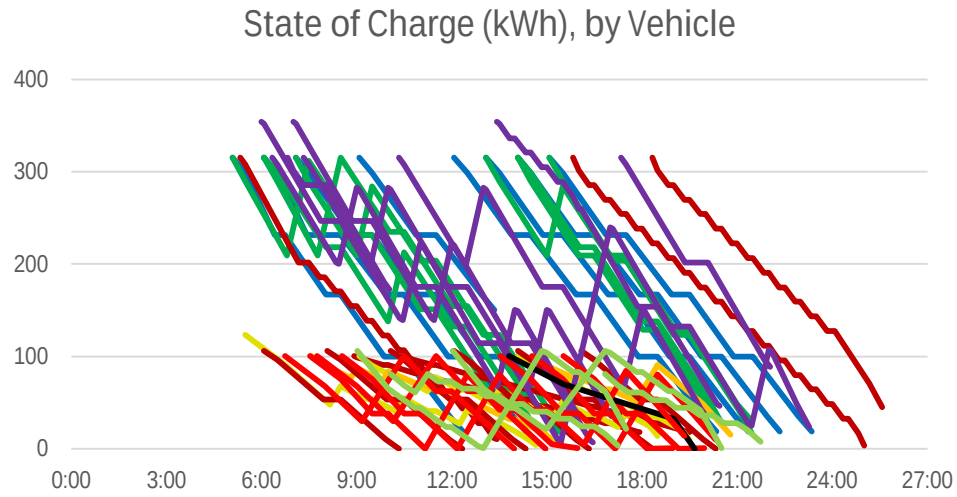
Hyannis (Midday)

Operations Modeling

Existing Operations



Recommended Alternative



Peak fleet requirement increases by four (8%):

- 2 cutaways: Sandwich
- 1 cutaway: Bourne
- 1 transit bus: Flex

Alternatively, schedule changes (longer layovers at charging locations) could reduce this need

Estimated Procurement Timelines

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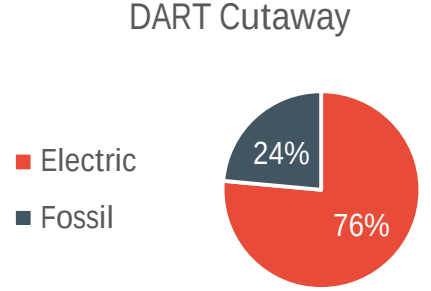
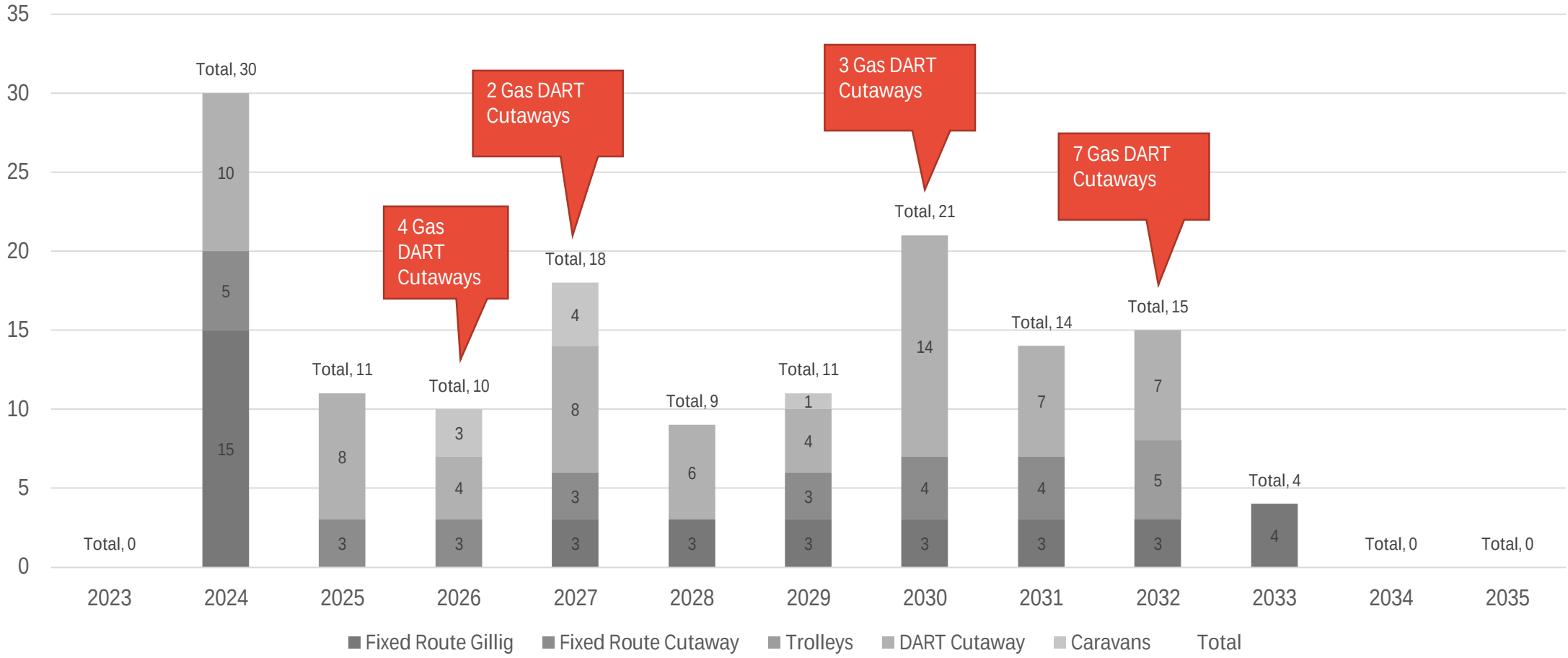
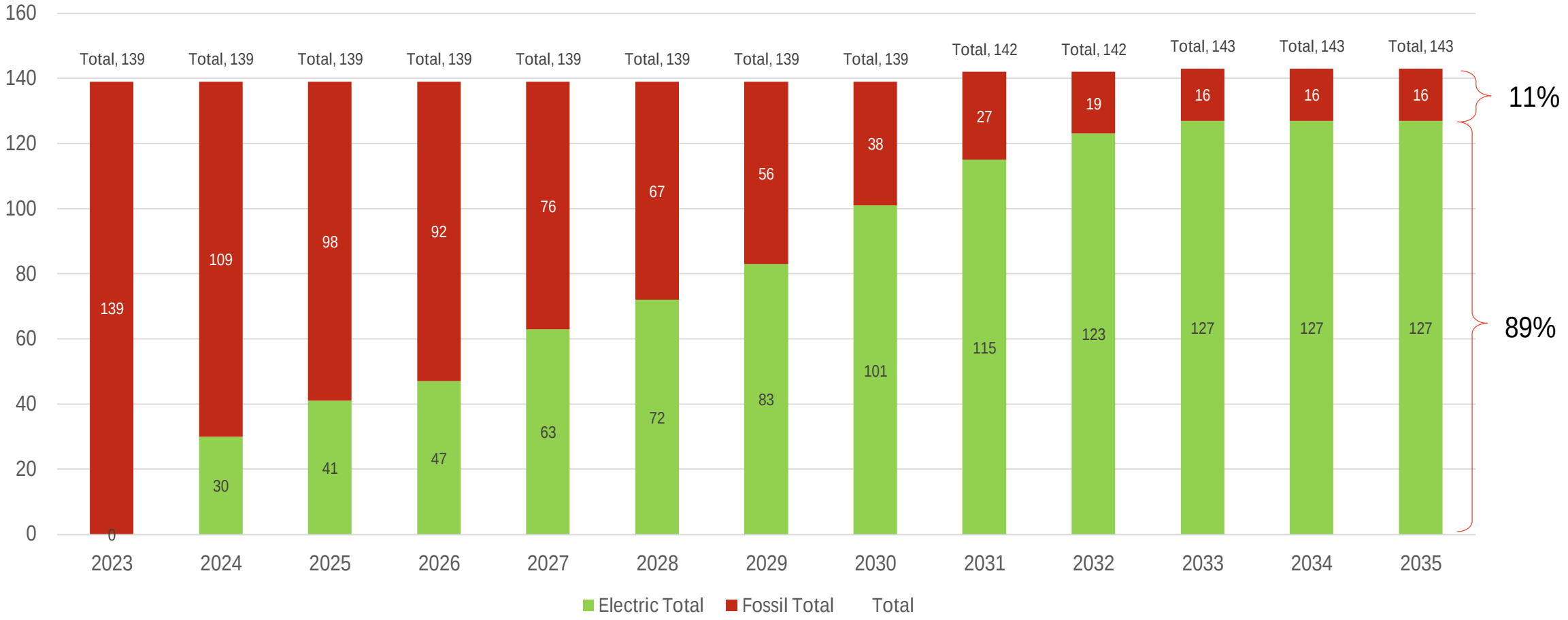
Vehicle Procurement Timeline

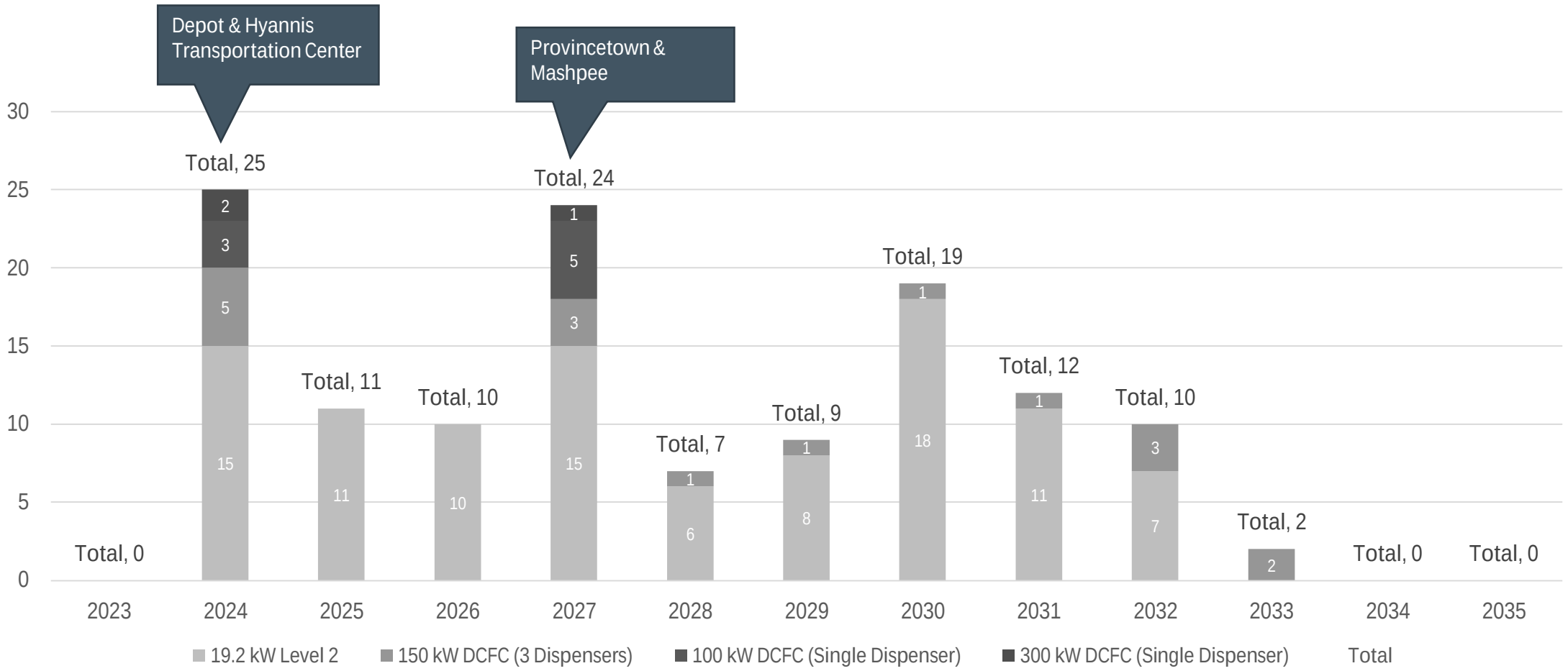




Fleet Composition



Charger Procurement Timeline



Charger Distribution

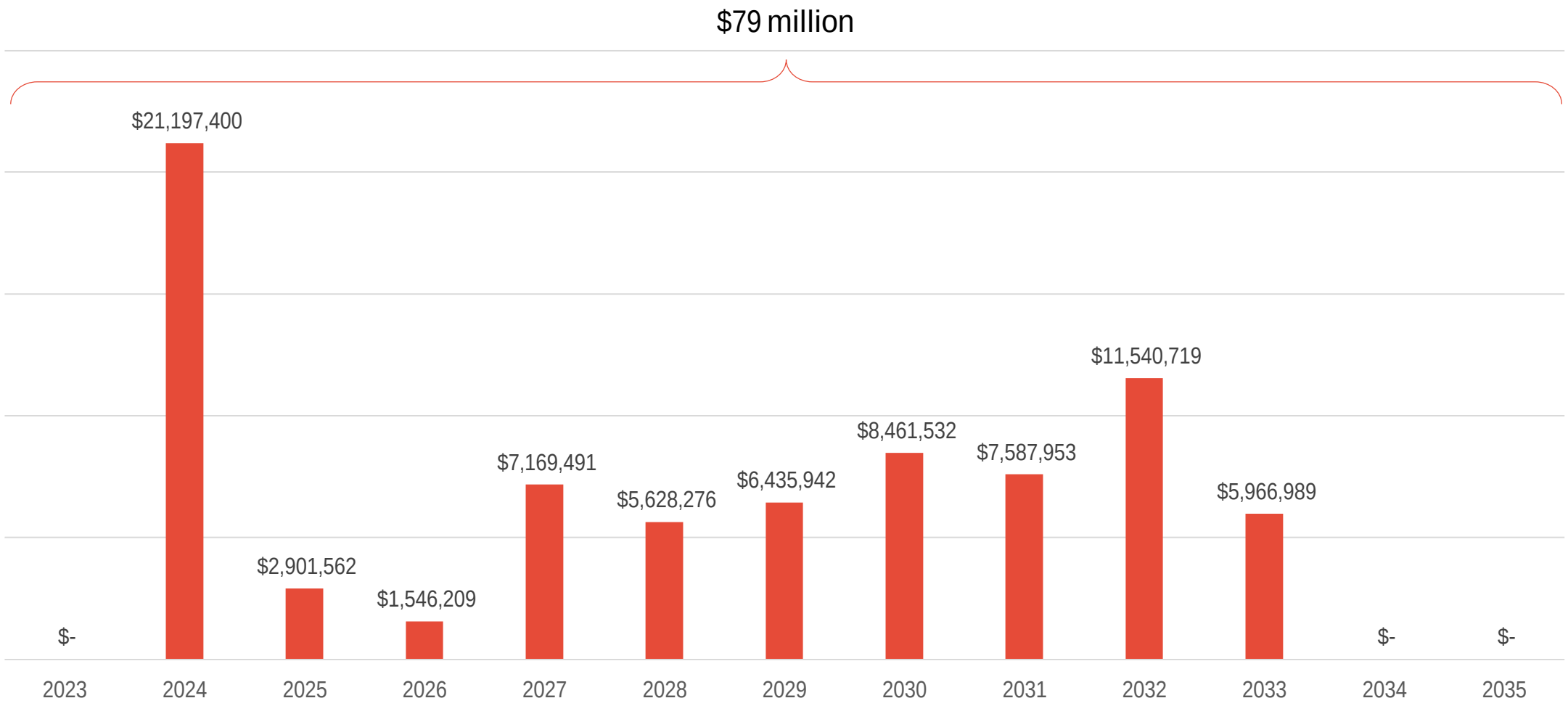
	Depot	HTC	Provincetown	Mashpee	Total
19.2 kW Level 2	101				101
150 kW DCFC (3 Dispensers)	15		2		17
100 kW DCFC (Single Dispenser)		3		5	8
300 kW DCFC (Single Dispenser)		2	1		3
Total	116	5	3	5	

Notes:

- 15 – 150 kW DCFC will equal to a total of 45 dispensers at the depot
- 2 – 150 kW DCFC will equal to 6 dispensers at the Provincetown
- The chargers at Falmouth are assumed to be public chargers and hence are not included in CCRTA's capital plan

Lifecycle Cost Analysis & Capital Plan

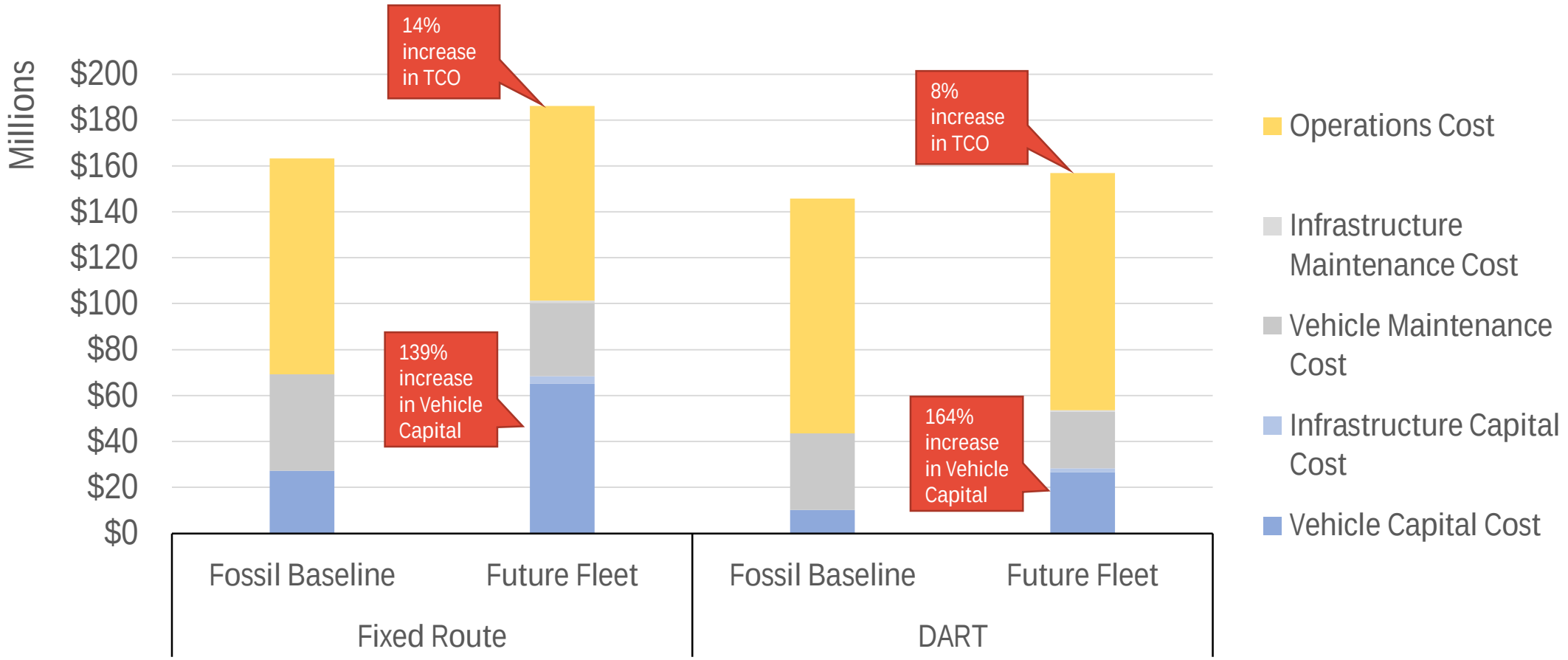
Capital Plan



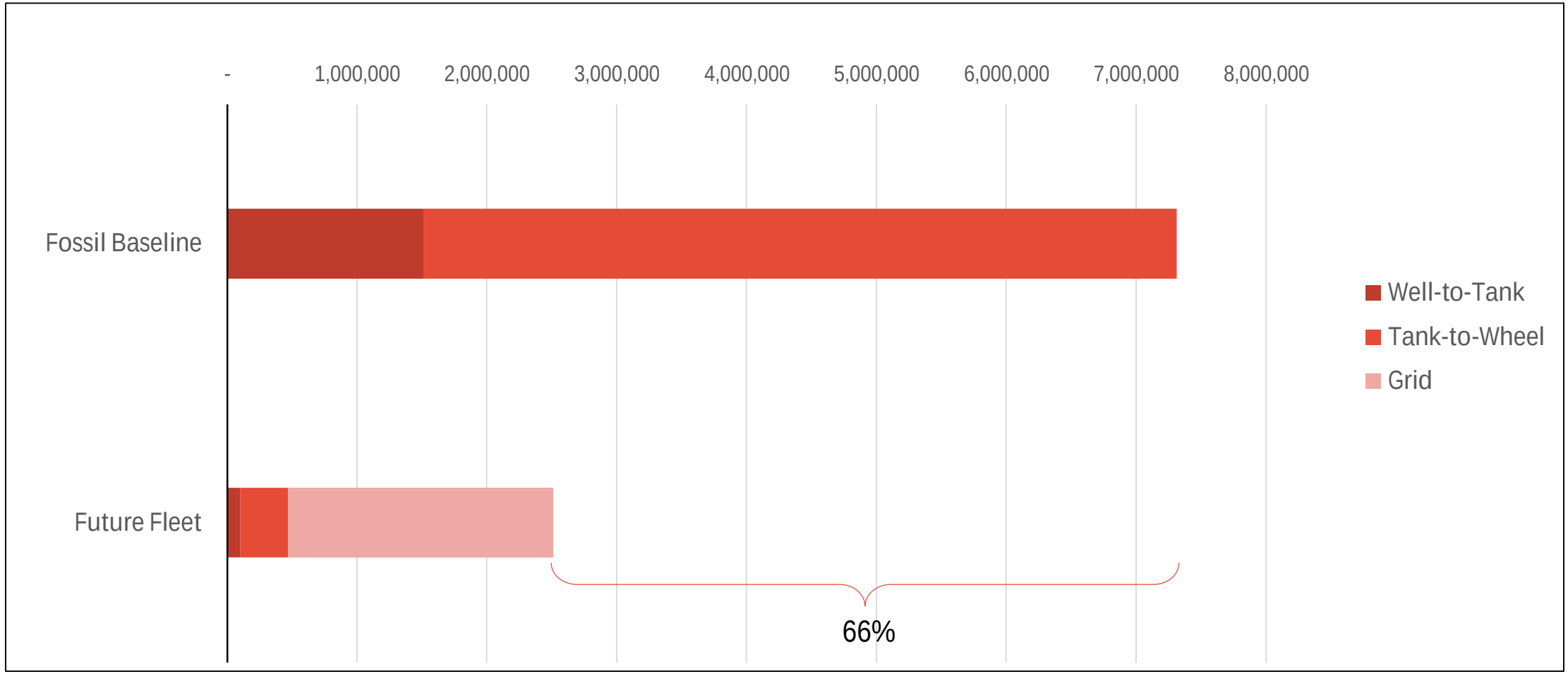
Assumptions for Lifecycle Cost Analysis

- General
  - 3% inflation
  - 12-year life for Buses
  - 7-year life for all other vehicles
- Fixed Route Vehicle
  - $75,000 battery warranty cost assumed
  - Diesel vehicle maintenance cost: $1.3/mile
  - Electric vehicle maintenance cost: $0.96/mile
- DART Vehicle
  - Gasoline vehicle maintenance cost: $1.25/mile
  - Electric vehicle maintenance cost: $0.92/mile
- Operator hourly cost: 43$/hour
- Charging
  - Construction costs were assumed to be covered by Eversource

Total Cost of Ownership



Annual CO2 Emissions (kg)



Market Options

Electric Vehicle Options

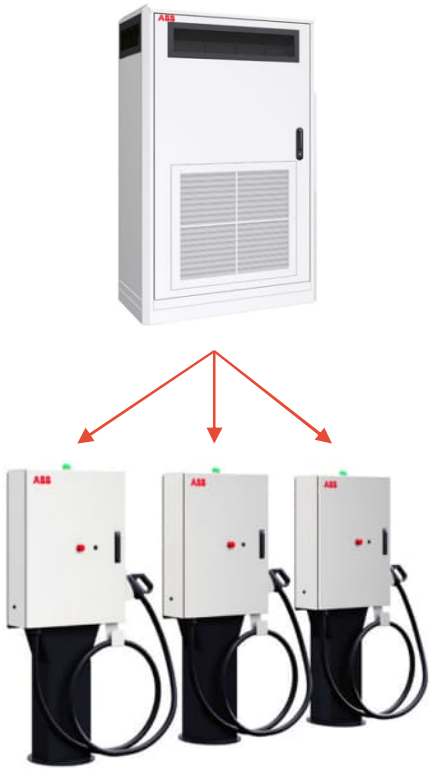
Vehicle	Electric Equivalent	Example(s)	Approx. Unit Price
Bus	30', 35' Bus	Gillig/New Flyer	$960,000
Cutaway/Minibus	Large, mid, and small-sized cutaways	Ford E Transit Cutaway/Lightning eMotors ZEV 3 & 4 Van/Ford Transit 350HD Passenger Van	$295,000, $170,000, $125,000
Caravan	SUV	Chevy Electric Equinox EV/Rivian R1S	$70,000
Trolley	Electric trolley	Hometown Villager/Streetcar	$800,000

Charging Equipment Options

19.2 kW Level 2

$7,500

150 kW DCFC (3 Dispensers)



$150,000

100 kW DCFC (Single Dispensers)

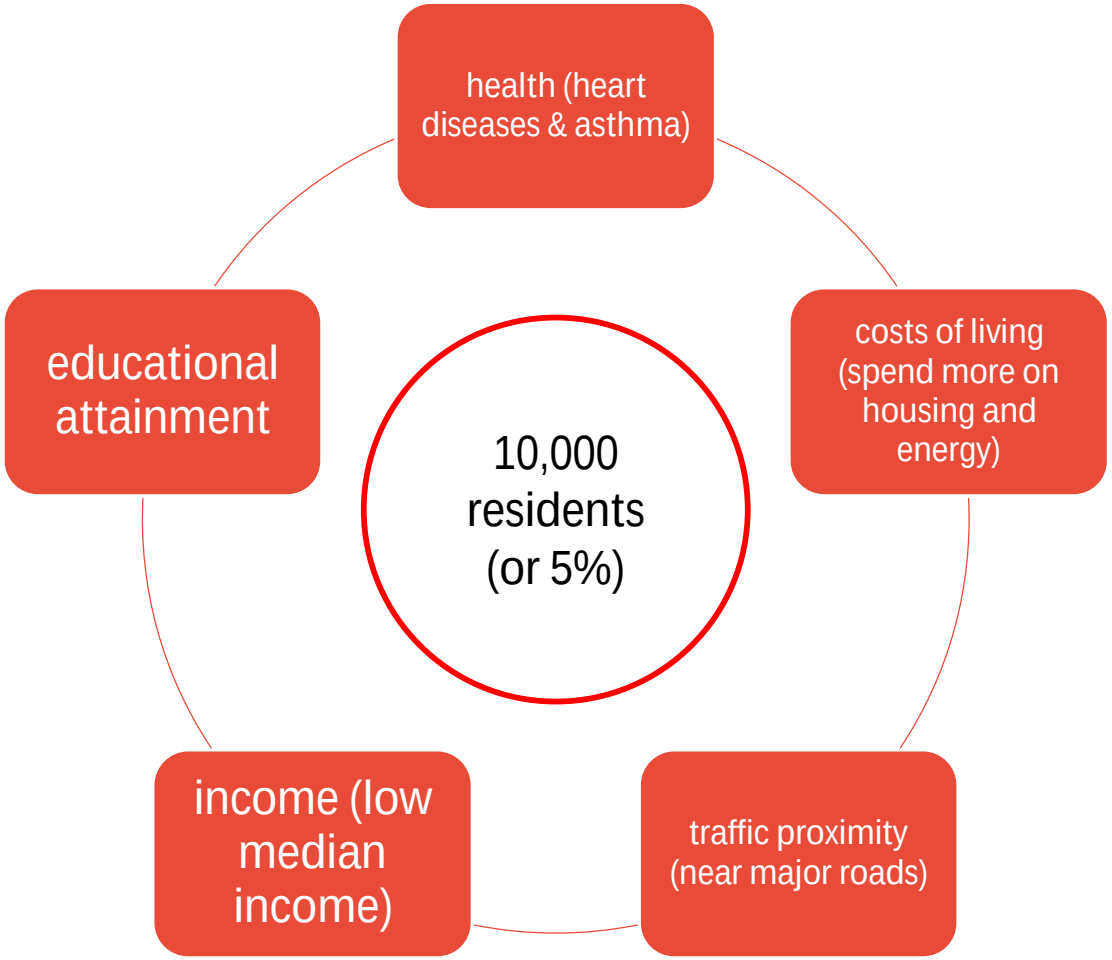
$110,000

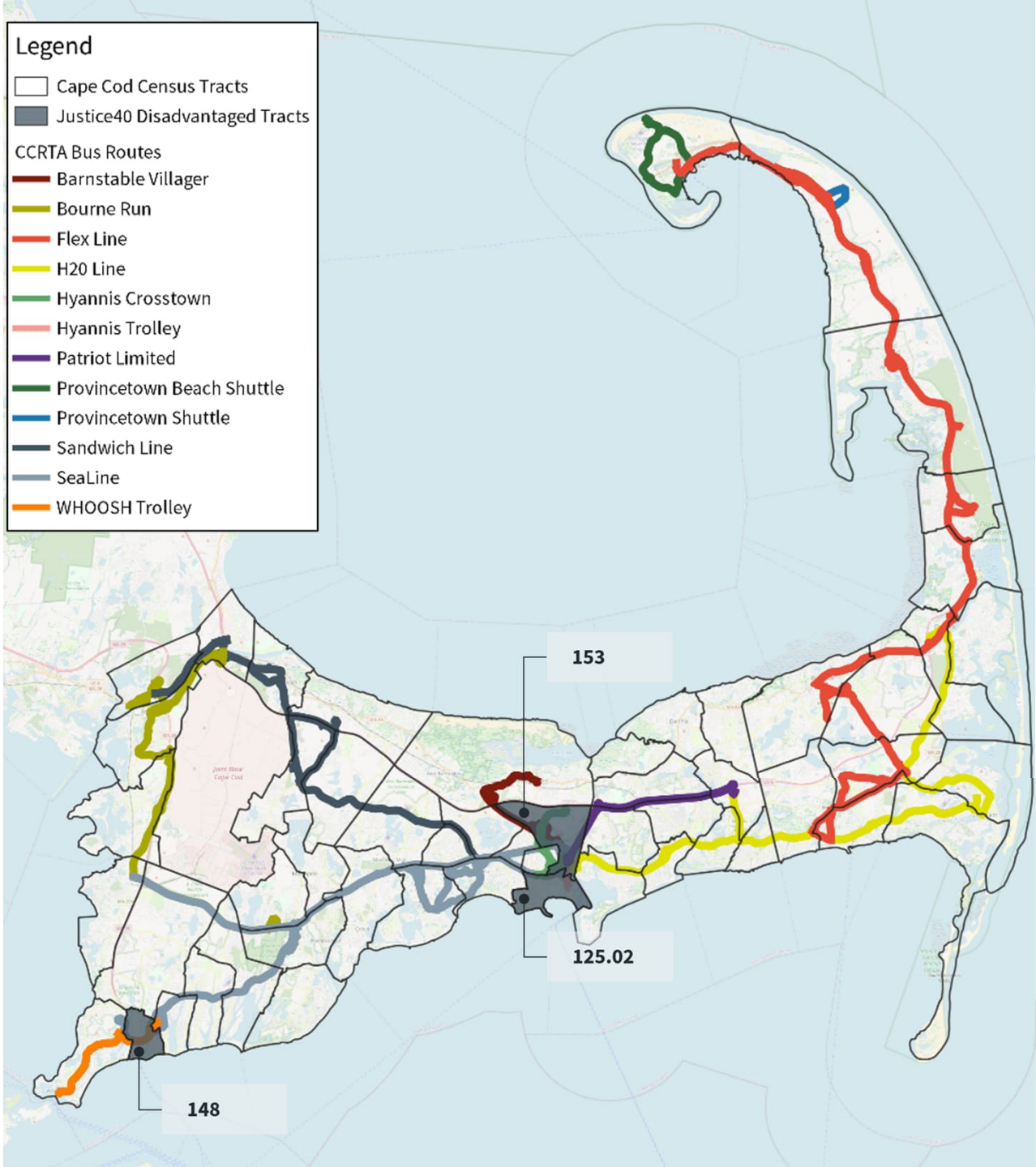
300 kW DCFC (Single Dispensers)

$200,000

Community Considerations

Findings: Justice40





Key Takeaways

Key Takeaways

- Fixed route is feasible for full fleet electrification
- Demand response appears feasible for 75% electrification
  - Continued monitoring of the market
- Start procurement process for Depot and HTC
- Continued Utility coordination
- Strategize charging at Mashpee/Provincetown/Woods Hole
  - Negotiations with local landowners
  - Where/layout
  - Coordination with Steamship Authority
- LCC – 11% Increase
- CO_2 Emissions – 66% Decrease

Next Steps

- Depot space proofing, planning, and utility coordination
- Begin outreach for workforce training
- Strategize around charging infrastructure at identified locations and additional charging opportunities

Questions

For more information,
please visit www.hatch.com

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