ECE 398GG – ELECTRIC VEHICLES

13. *The EV Charging Infrastructure (EVCI):*

Social and Technical Considerations in

EV Supply Equipment (EVSE) Placement Strategy

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BARRIERS TO EV ADOPTION

- ✓ ❑ **Access to en-route charging infrastructure**
- ✓ ❑ **Limited battery range**
- V ❑ **High capitol cost**

All contribute to "Range Anxiety": the worry that an EV battery will deplete its charge prior to access to available charging.

How can we alleviate these public concerns? We suggest strategic placing EVCI to extend the range => to facilitate trips outside of EV range

Driving and Parking patterns

- Only few trip exceed the average range of an EV
- If drivers were willing to change driving habits only 10 times in a year, 75% of drivers could meet their transportation need for remaining days of the year with a 150 mile range
- Range anxiety is likely to occur during the infrequent long-distance events each year.

↳ number of trips >150 miles occurs only 10 days a year for 75% drivers

Proposed strategic framework for EVSE placement

part of daily routine

- ❑ Home charging

parking is a primary goal, having EVSE is added benefit vs en-route charging – recharging is a primary function

- ❑ Destination charging: charging at locations in which you already intend on spending time
- ☑ Add a proposed Critical Recharge Zone (CRZ) is geographic region where EVs require recharge
- ☑ The addition of CRZ will increase the range of travel for EVs, reducing driver's range anxiety for long trips

Let's evaluate two way to approach range anxiety:

Large Battery vs. Fast Charge

Table 1: Stated Value and Market Cost

	Battery Range V	Charging Speed V
2011 Hidrue Survey	$1,750 - $3750 per additional 50 mile of battery range	$6,555 for a car that (can charge 50 miles in 1 hour)
2014 Market Price	$5,600 per additional 50 mile of battery range (Tesla)	$4,500 for a 19 kW EVSE (can charge 50 miles in 44 min) $30,000 for a 40 kW DC EVSE* (can charge 50 miles in 21 min)

people were ready to pay $35 - $75 per extra mile

$112 per extra mile of a battery range

↳ $61 per mile ⇒ ≈ $3000 per 50 miles

adding 50 miles driving range

Socialized cost for 20 drivers:

$4,500 19 kW EVSE Installation / 20 users = $225 per user
$30,000 40 kW EVSE Installation / 20 users = $1,500 per user

Activity:

- 2022 Nissan Leaf with a battery capacity of 40 kWh advertises a driving range of 149 miles. How much capacity in kWh is required to drive for 50 miles?

  $Eff = \frac{149 \text{ miles}}{40 \text{ kWh}} = 3.7 \text{ miles/kWh} \Rightarrow \frac{50}{3.7} = 13.4 \text{ kWh}$ ✓

- Assume that the EV charges at a 19 kW EVSE. How much time is needed to charge enough for 50 miles driving?

  ✓

  $E = P \cdot t \Rightarrow t = \frac{13.4 \text{ k}}{19 \text{ k}} = 0.7 \text{ h} \approx 42 \text{ min}$

- What about charging at 40 kW EVSE?

  20 min $t = \frac{13.4 \text{ k}}{40 \text{ k}} = 0.3 \text{ h}$ or 20 min

EVSE Placement Strategy

Purpose of CRZ is to place EVCI in locations that will facilitate the greatest number of long-distance trips

		Social Variables	Technical Variables
1	Locating the CRZ	Trip Origin / Destination Common Routes ↳ high volume of traffic	Range limitation for EVs
2	Siting EVSE within CRZ	Signage Local Entertainment	Distance from Corridor Service Power at Site

↑ population density and employment density

Two assumptions:

1) EV owners have EVSE at home
2) EV owners have EVSE at destination

Determine Parameters

limitations of EV range

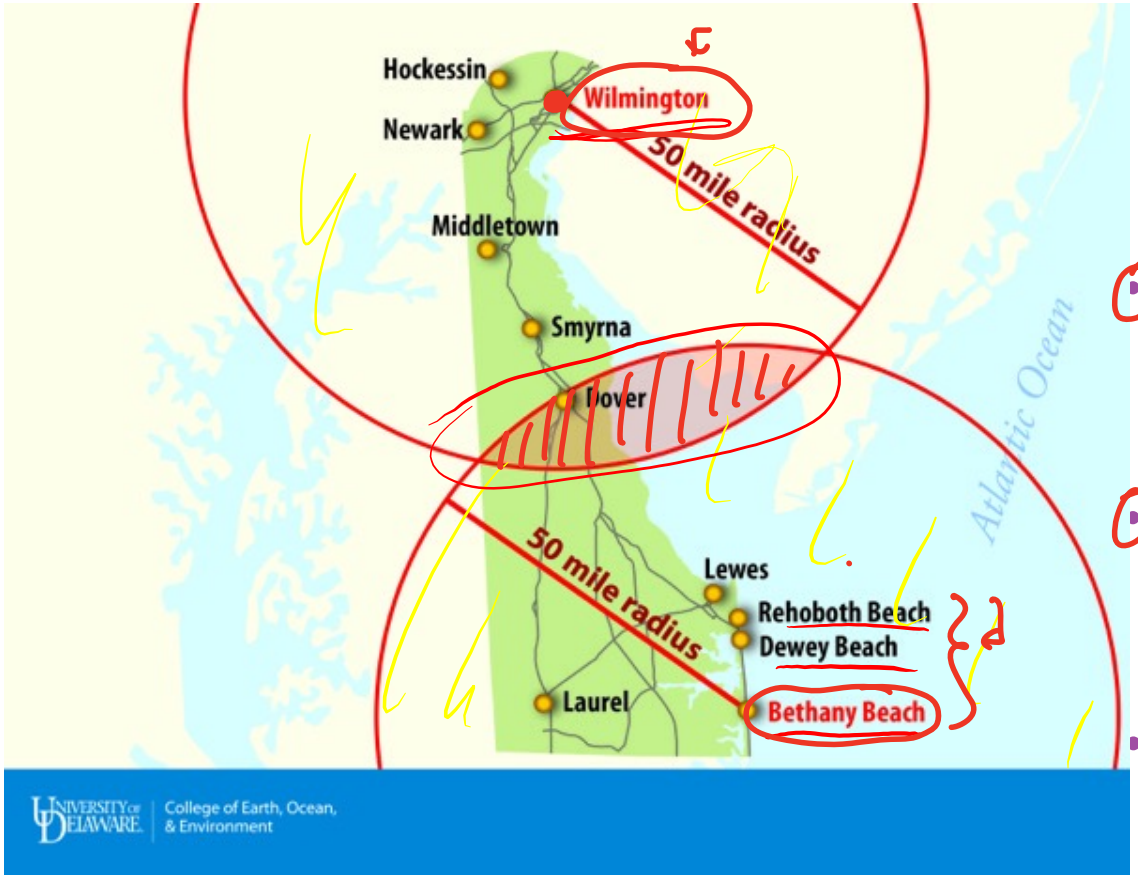
* Nissan Leaf used as baseline:
  * Lowest range on market (Average of 73 miles/ charge)

    But can't count on 73 miles, lowered by:
    * driving styles
  * Air-conditioning/ Heating
  * Cold battery

    ↕ operating conditions

50 miles used as a "worst-case scenario"

Locating the Critical Recharge Zone



- 50 mile radius circles were drawn around each major city
  - Ensures "worst-case scenario" is met.
- Circles were clipped to fit major roads
- The routes were overlaid
  - This created a "Critical Recharge Zone" (CRZ)
- The CRZ:
  - South Dover

Siting within the CRZ

The process of site-specific placement can be expressed as the calculation of a driver as they approach the need for a charge. Four of those primary questions are:

1. **How far off the highway is the charging station?**
2. **Are there signs to direct me to the charging station?**
3. **How long will it take my car to charge?**
4. **What will I do while my car charges?**

Siting criteria

En-route charging for a long distance travel → not destination ↓ not frequently used

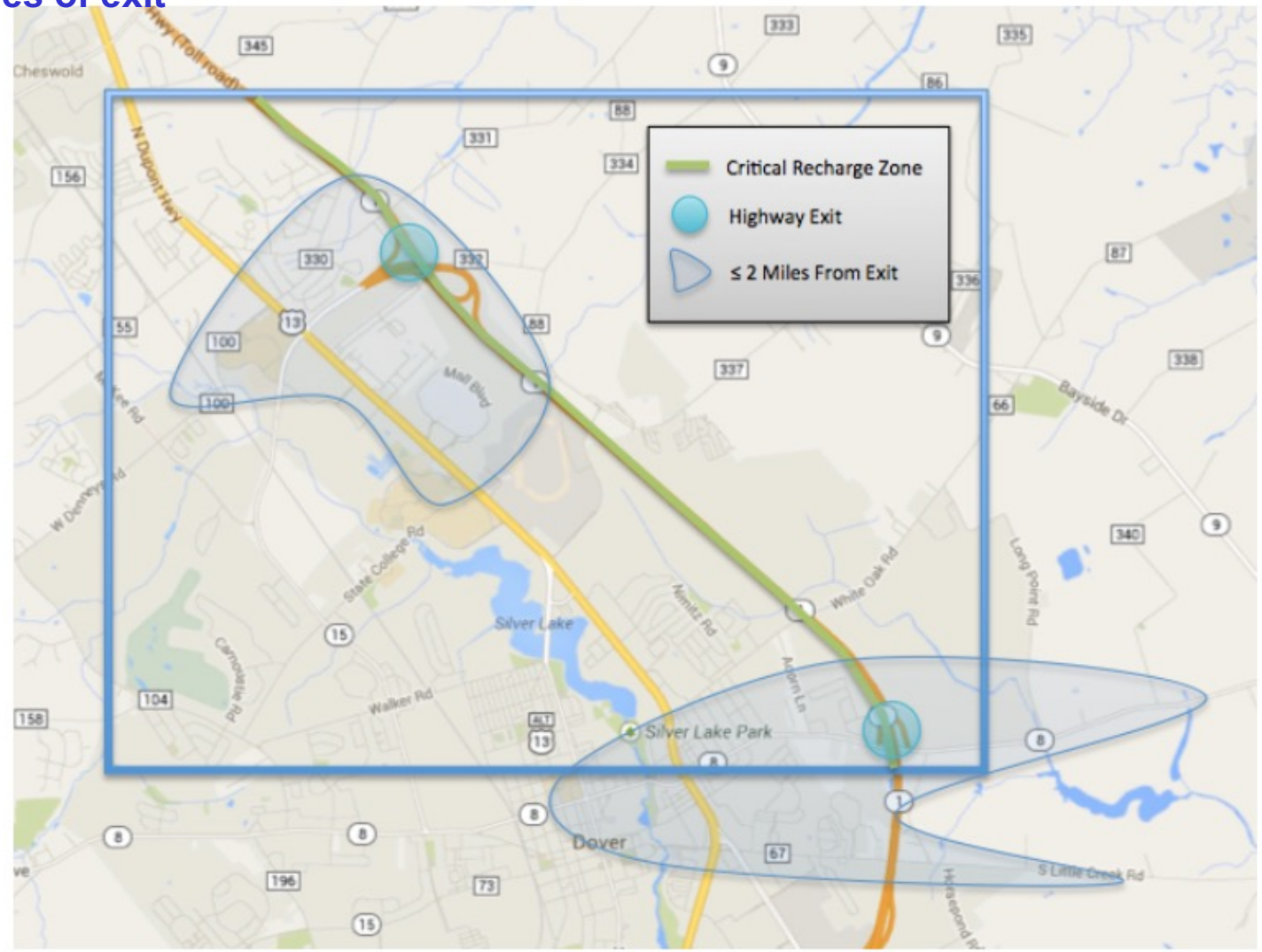
- ✓ **Distance from travel corridor** (≤ 2 miles; minimize the distance from the corridor to a charging station)
- ✓ **Signs to find location** (≈ 5% of average battery range)
- ✓ **Power supply sufficient for at least 19.2 kW**
- ✓ **Recreational activities or food** : consider time spent and frequency :

"good option" { eating, shopping, movies

Dep. of Motor Vehicle : not very often, however takes ≈ 2 hours

Example of siting within the CRZ

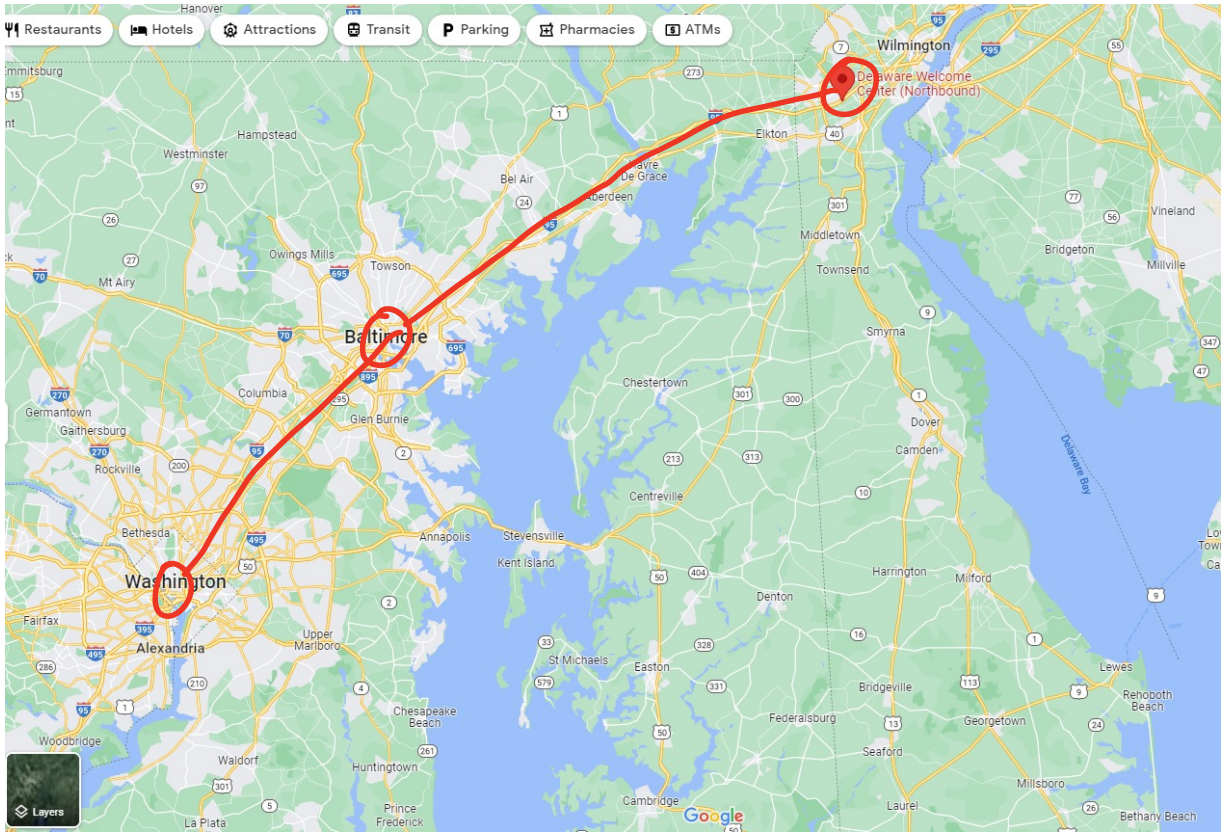
within 2 miles of exit



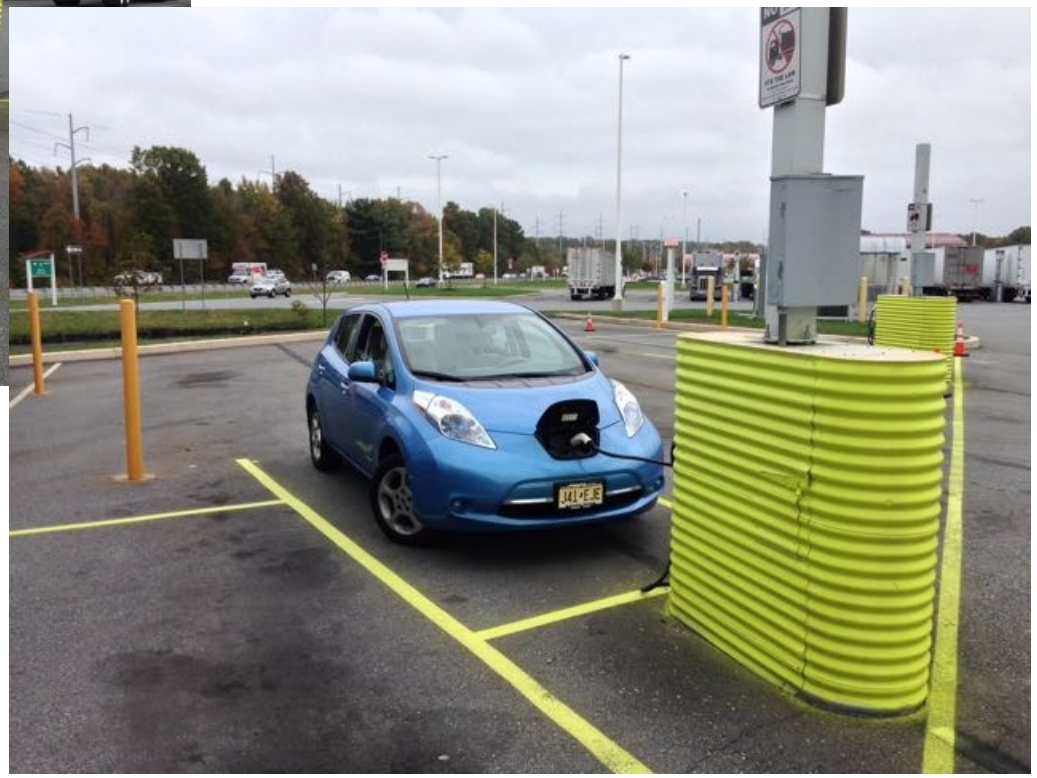
I-95 Welcome Center

- Allows for en-route charging

- Travel to Dover (and therefore beaches)
- Travel to Maryland (and therefore Baltimore and D.C)
- Designed Signs for Site
  - activities: food court



I-95 Welcome Center



Pictures taken from user postings on PlugShare

√ Surfside Park-Rehoboth Beach

- Serves as destination charging

- Allows EV drivers in Delaware to be able to take day-trips to Rehoboth Beach