Electrification of the Freight System in Minnesota: Barriers, Opportunities, and a Multicriteria Planning Tool

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Presentation Overview

Part 1: Barriers and Opportunities in Adoption of Electric Trucks

Part 2: A Multi-criteria Decision Analysis Tool for Charging Station Locations Planning

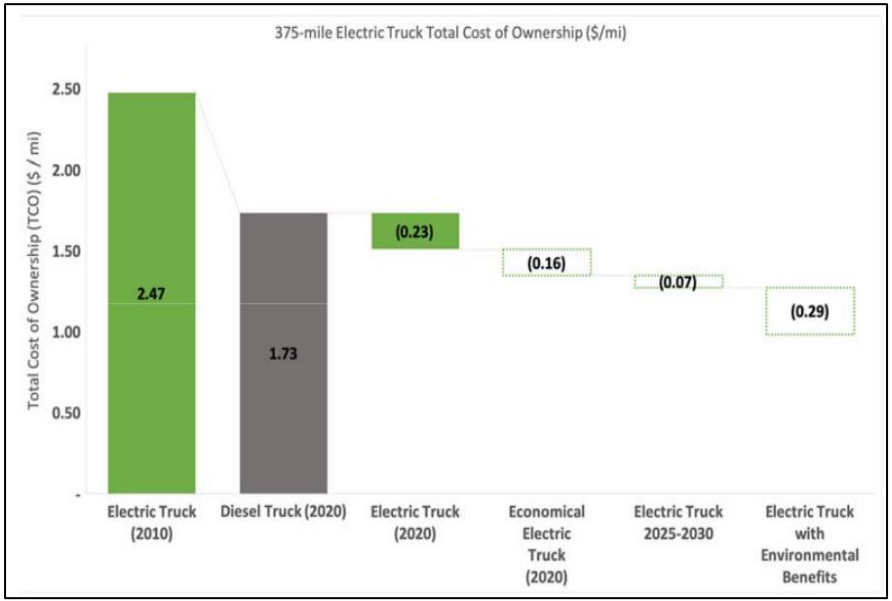
Part 1
Barriers and Opportunities in Adoption of Electric Trucks

Barriers to Electric Trucks Adoption

1. Technical Performance
   - Infrastructure
   - Driving Range
   - Charging Time
   - Battery Cost and Life Cycle
2. Operational Performance
   - Charging Pattern (overnight vs. *en route*)
   - Loading Capacity
   - Repair Facilities and Technicians
3. Economics Barriers
   - Initial purchase cost
   - Battery replacement cost
   - Independent operators and small businesses may not afford it
4. Utility Perspective
   - Grid Capacity
   - Upgrading Cost
   - Business Model Uncertainty

Electric Trucks' Benefits and Opportunities

1. Economic Benefits
   - At current battery price ($135/kWh), class 8 operating 300 miles/day:
     - 13% lower ownership cost than diesel trucks ($1.51 vs $1.73 per mile)
       - ➔Initial cost payback in 3.2 years
       - ➔$200,000 saving in 15 years
   - At 2030 battery price ($60/hWh):
     - 40% lower ownership cost



Why regional and long-haul trucks are primed for electrification now. Lawrence Berkeley National Lab.(LBNL), 2021.

Electric Trucks' Benefits and Opportunities (cont.)

2. Environmental Benefits
   - GHG reduction is another $0.29 saving per mile
   - Lower GHG emissions improves the health and livability of communities
3. Operational Benefits
   - Energy regeneration and better maneuverability in traffic congestion
   - Taking more direct routes through urban areas (better routing, time/mileage saving)
   - Potential operation in low-emission zones in urban areas
   - Extended operation time window in urban areas due to less noise
4. Opportunities for Policies and Incentives
   - Financial support: purchase cost incentives, energy incentives
   - Promotional policies: routing, low-emission zoning, extended operation time windows

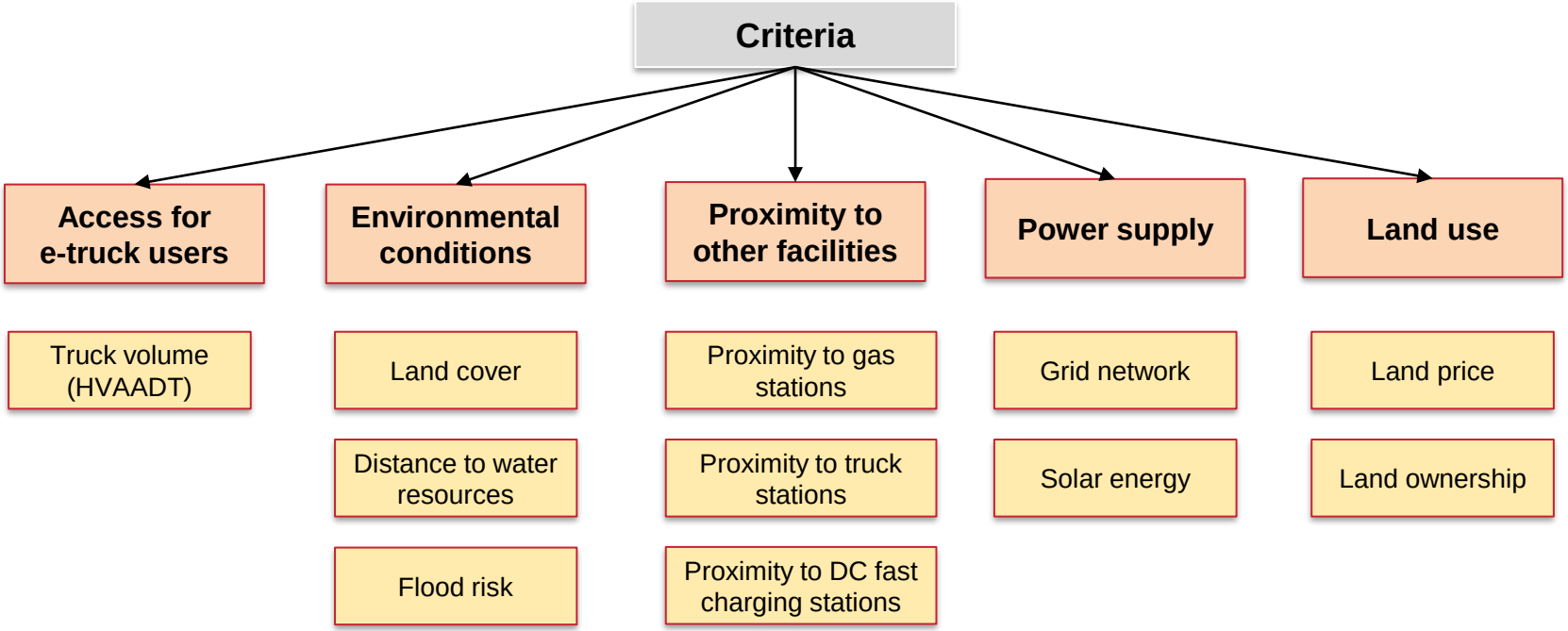
Part 2

A Multi-criteria Decision Analysis Tool For Charging Station Locations Planning

OBJECTIVE

1. Identify the corridors of Minnesota highway network where public charging stations are most needed
2. Optimize the location and type of e-truck charging stations on Minnesota highway network

Criteria Structure

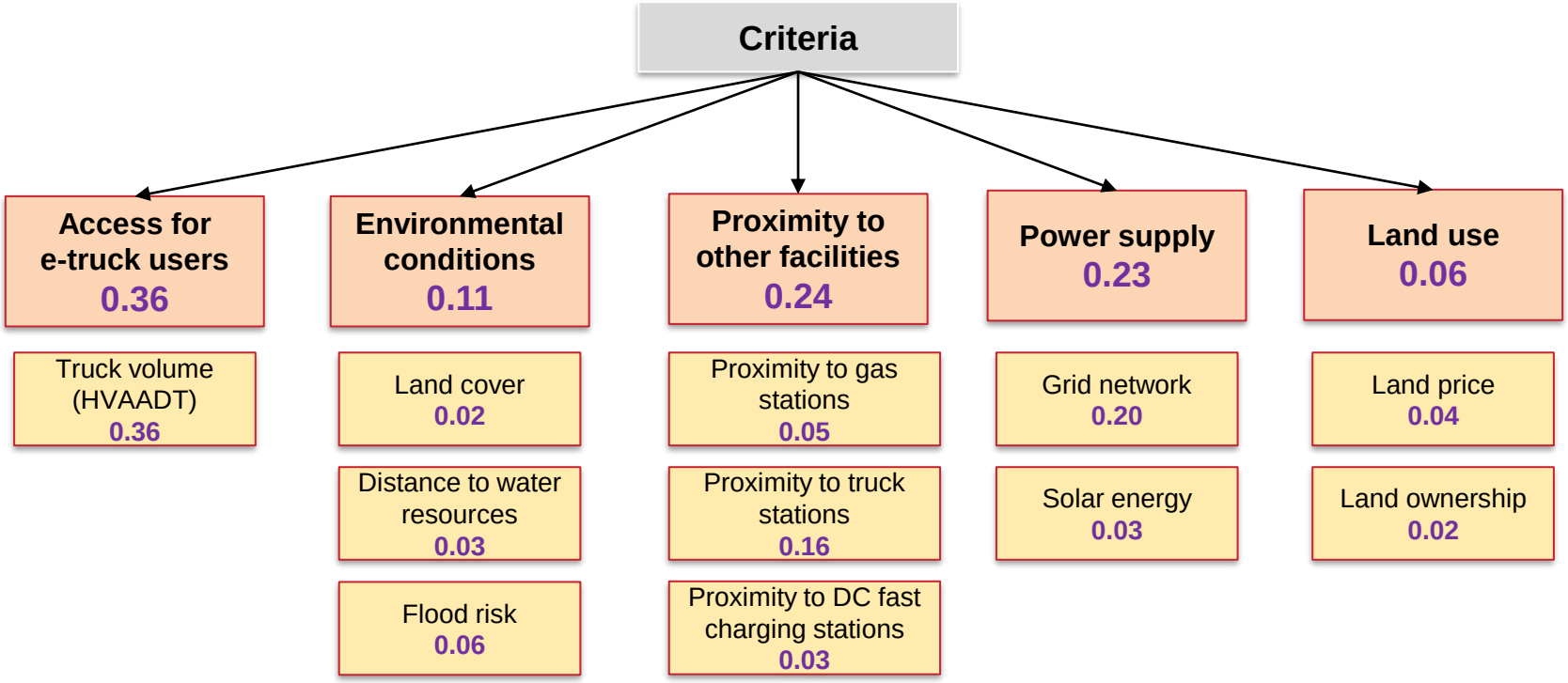


Expert Survey

- Objective: to estimate criteria weights based on expert knowledge
- Method: pairwise comparison of the criteria
- Recipients: experts and stakeholder (MnDOT, ATRI, FMRI, ATA, HDR, etc.)
- Responses:16 responses with 11 meeting the consistency conditions

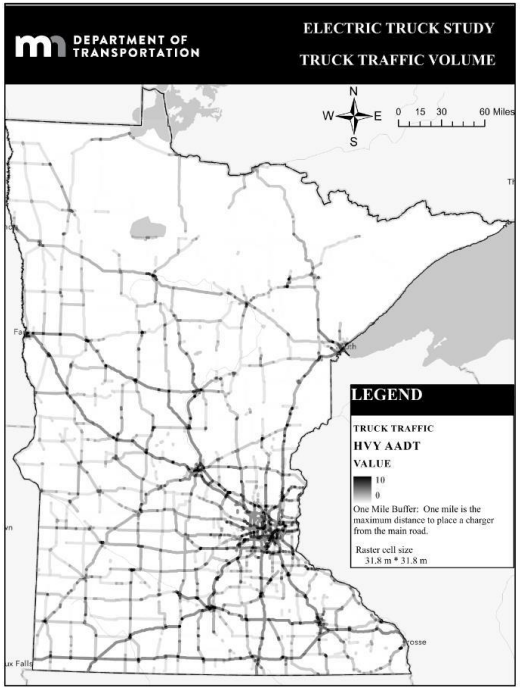
	9	8	7	6	5	4	3	2	1	1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9
"Accessibility" is ... times important than "proximity"	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
"Accessibility" is ... times important than "Environmental conditions"	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
"Accessibility" is ... times important than "Power supply"	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
"Accessibility" is ... times important than "Land Use"	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Criteria Weights (Survey Results)

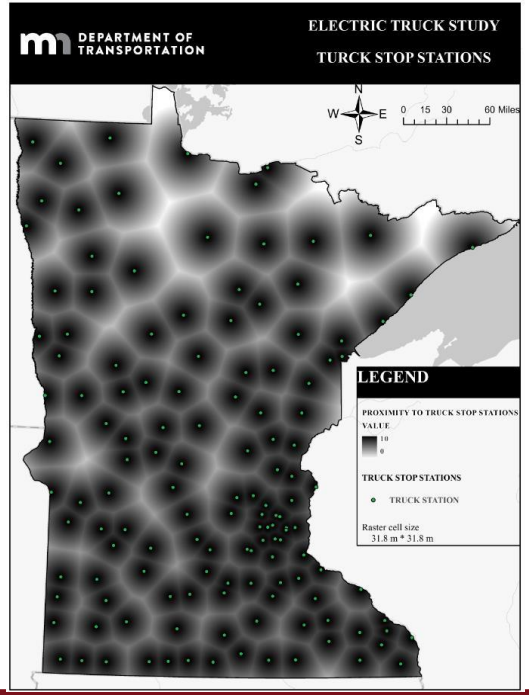


GIS Analysis of The Criteria (sample)

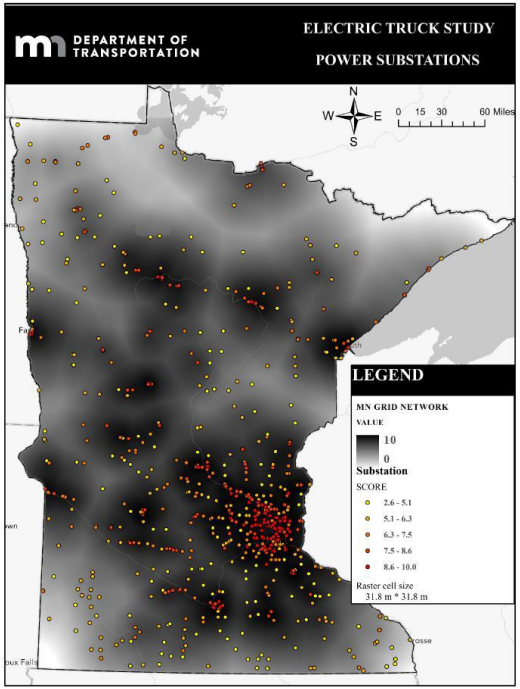
Truck Traffic Volume



Truck Stations



Power Substations



Power Supply Analysis

Proximity to electrical substations (50%)

Proximity to electrical substations	< 0.5 miles to Interstate/Freeway (Functional Class 1 & 2)	10
	0.5 - 1 mile to Interstate/Freeway (Functional Class 1 & 2)	9
	< 0.5 miles to Remaining US Highways/Trunk Highways (not an interstate/freeway) (Functional Class 3)	8
	0.5 - 1 mile to Remaining US Highways/Trunk Highways (not an interstate/freeway) (Functional Class 3)	7
	< 0.5 miles to Other Principal Arterial (Functional Class 4)	4
	0.5 - 1 mile to Other Principal Arterials (Functional Class 4)	3

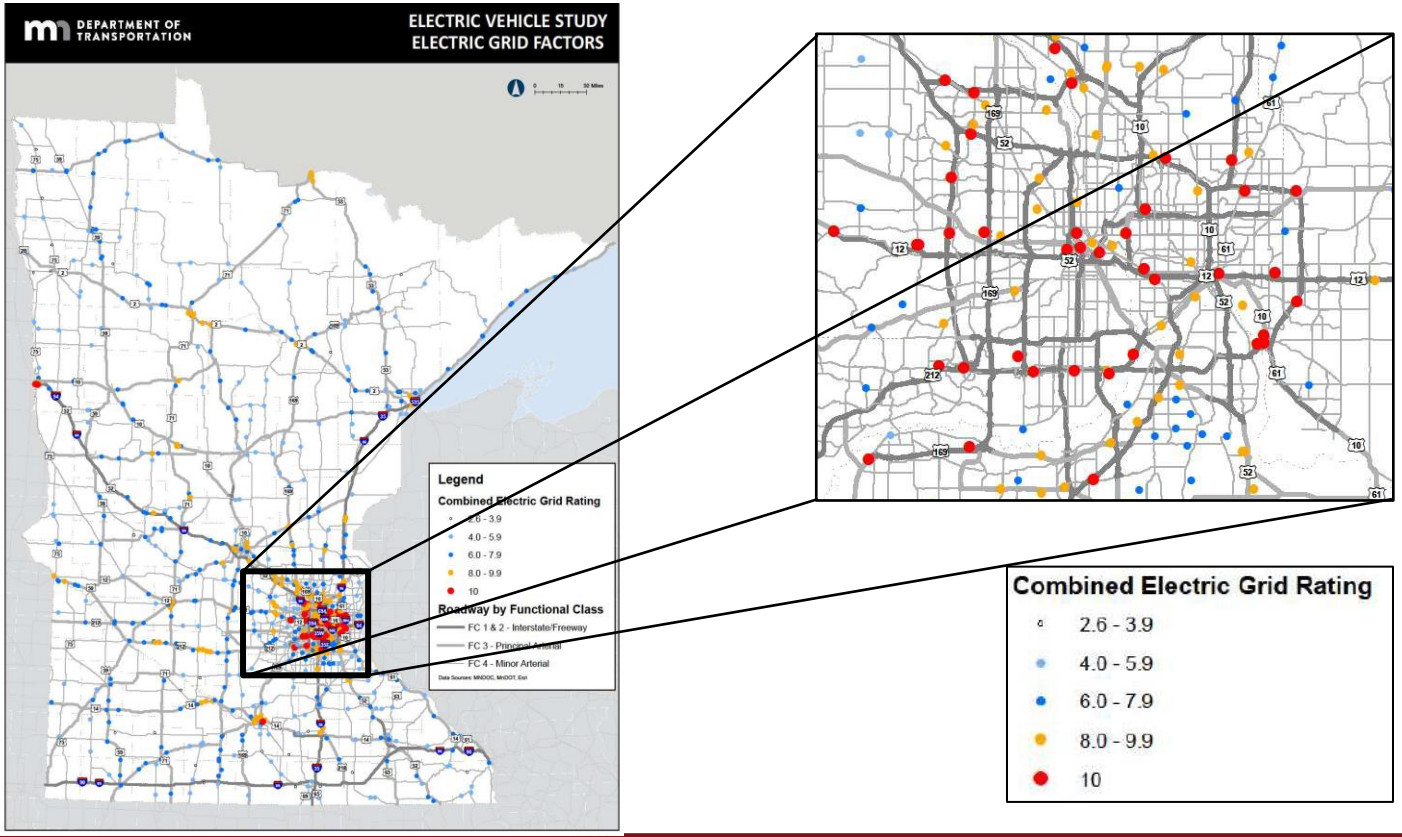
Capacity of electrical substations (30%)

Power capacity of electrical substations	Lowest Voltage 115kV (20+ MW Power Capacity)	10
	Lowest Voltage 69kV (10+ MW Power Capacity)	7

Power reliability (20%)

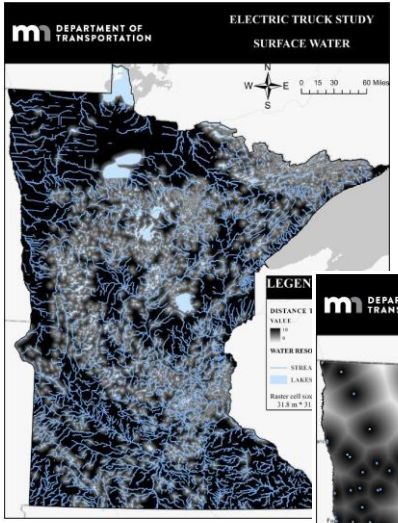
Power reliabilty	3+ substations within a 5-mile buffer	10
	2 substations within a 5-mile buffer	7
	1 substation within a 5-mile buffer	3
	0 substations within a 5-mile buffer	1

Power Supply Analysis (cont.)

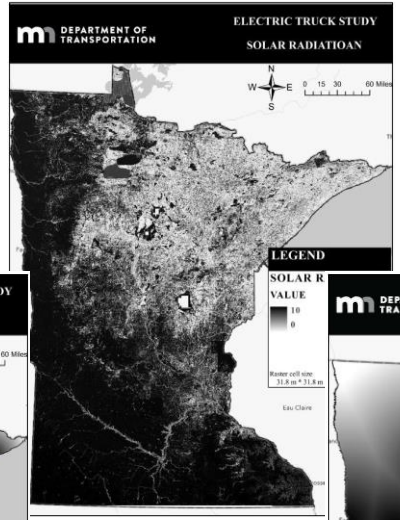


GIS Analysis of The Criteria (cont.)

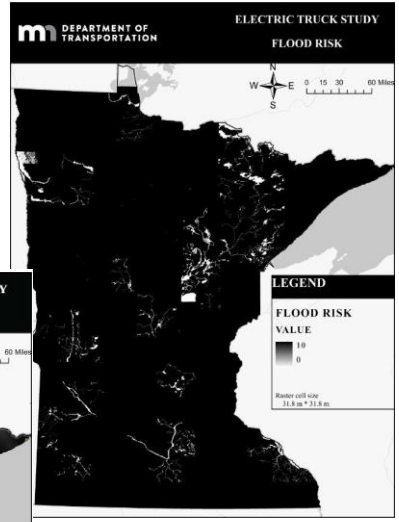
Bodies of Water



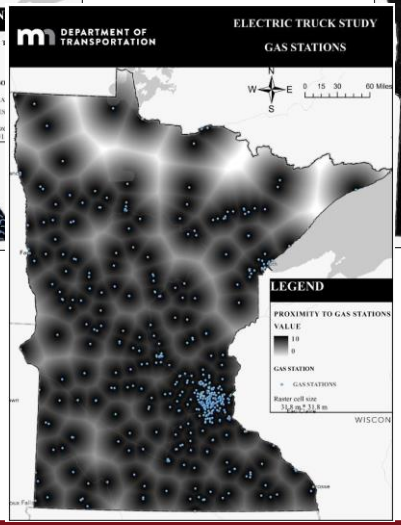
Solar Radiation



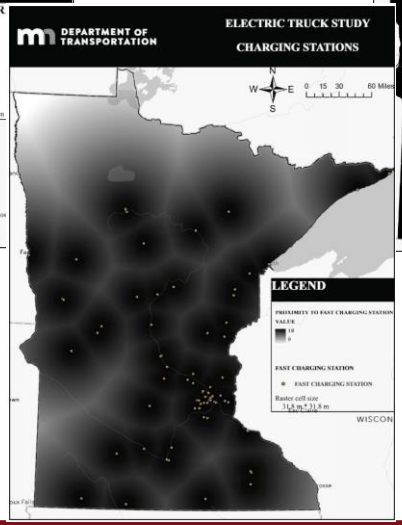
Flood Risk



Gas Stations

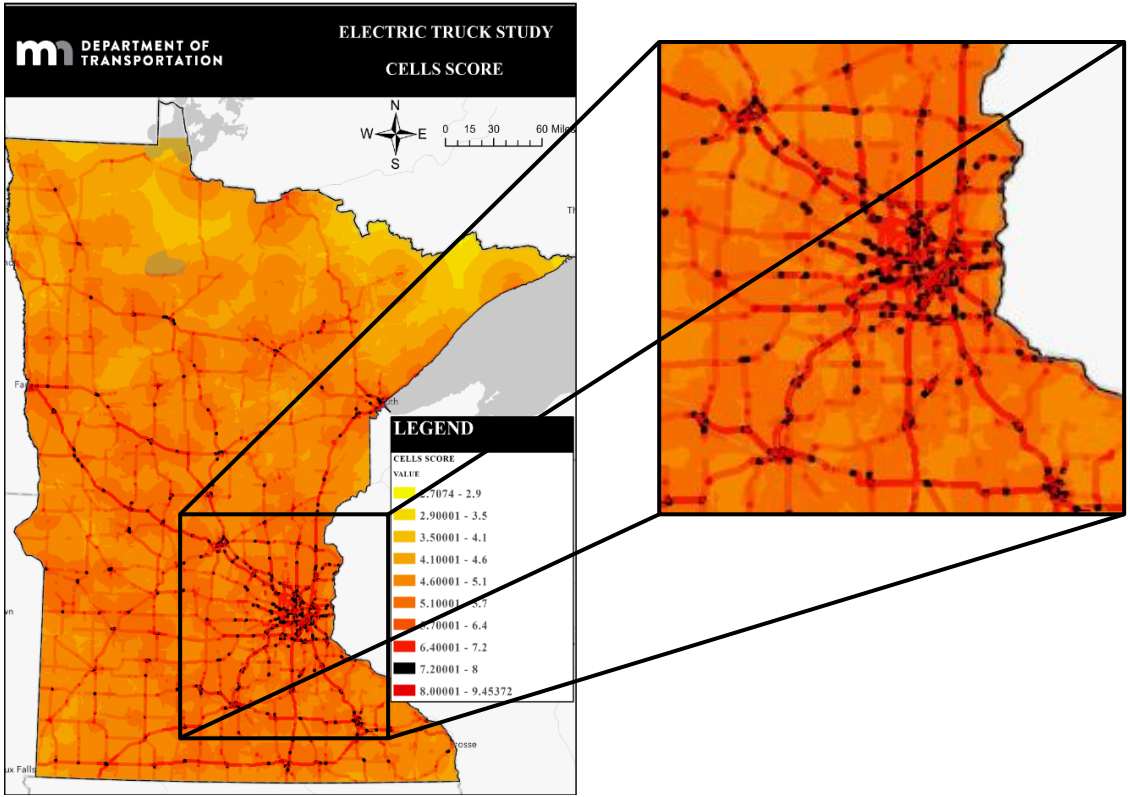


DC Chargers



Multicriteria Decision Analysis

1. The state was divided to pixels of ¼ acre
2. A 0-10 score was calculated for each pixel based on:
   - GIS analysis of the criteria
   - Criteria weights
3. Pixels with score >8 are identified as *candidate* locations for charging station



Top Corridors for Electrification

- I-35 from Albert Lea to Duluth
- I-94 from Lakeland to Fargo
- I-90 from La Crosse to Luverne
- US 10 form Cottage Grove to Moorhead
- US 169 from Elmore to Grand Rapids

Next Steps

- The identified locations are *candidate* locations only
- Further analysis is needed to:
  - Remove/merge duplicates
  - Fill gaps in major freight corridors
- An optimization model will be developed considering:
  - Truck origin-destination trips
  - Charging capacity and cost
  - Budget and other constraints

Conclusions

- Adoption of electric trucks will not be easy at the beginning, proper government policies and incentives are needed
- Among several barriers, we study the planning and optimization of charging stations
- Our approach is general and can be applied to other locations and/or with different sets of criteria

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