Electric Truck Charging Infrastructure: Investments and Impacts

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Transportation

https://youtu.be/OKUD9p3Xmoc

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Introduction

Electrifying trucks is a hard and impactful problem:

- Increased relevance due to recent mandates, e.g. California policy on electric truck sales
- Shorter distance travel can be electrified more easily, but long-haul freight is a tough problem
- Trucks can not use passenger car charging networks due to power and size constraints

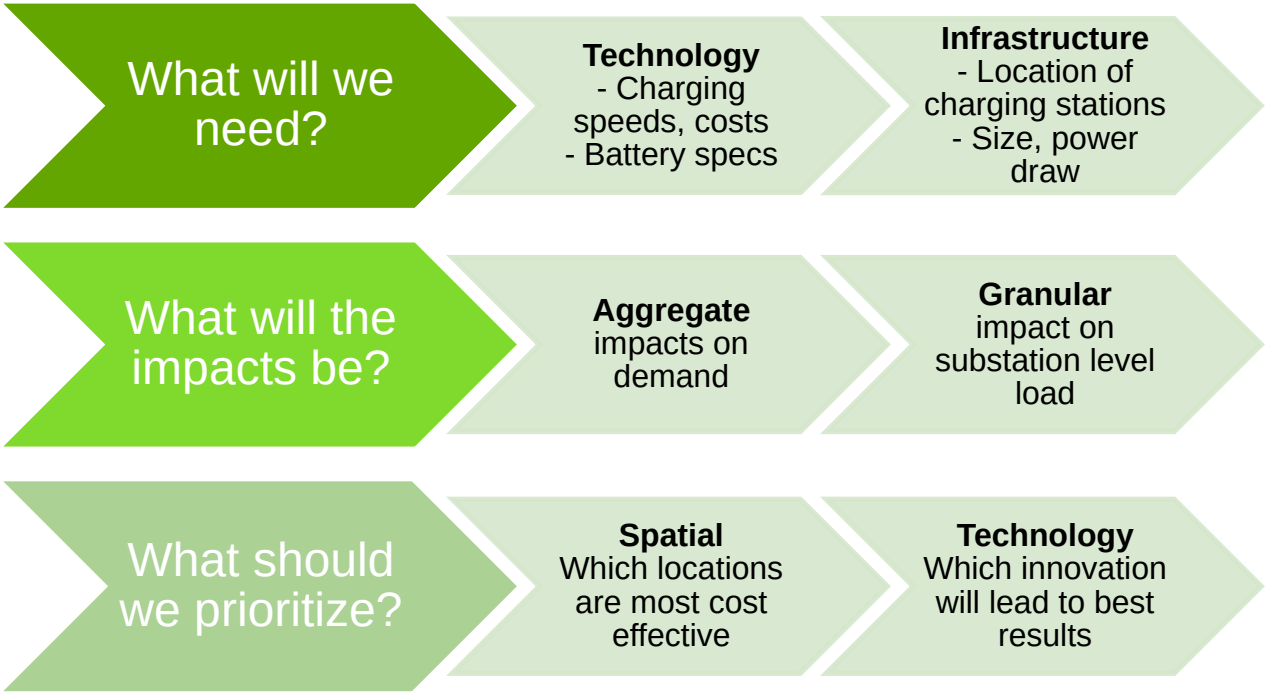
Huge carbon impact: 28% of US GHG emissions come from transportation; 6.4% from heavy duty trucks

Technical Innovation needed: Need bigger batteries for larger distances, with high energy density to comply with weight limits

Infrastructure outlay: no fixed routes for long haul trips which creates a need for public charging infrastructure

Grid Impacts: If all truck traffic were to be electrified, would lead to 10% increase in load (~1000 GWh per day)

Objective



Factors of interest:

- Charger technologies: speed and cost
- Energy prices: spatial and temporal variation
- Truck range: miles driven on a full charge
- Battery prices
- Labor costs/wages
- Electrification levels for regional and long-haul traffic

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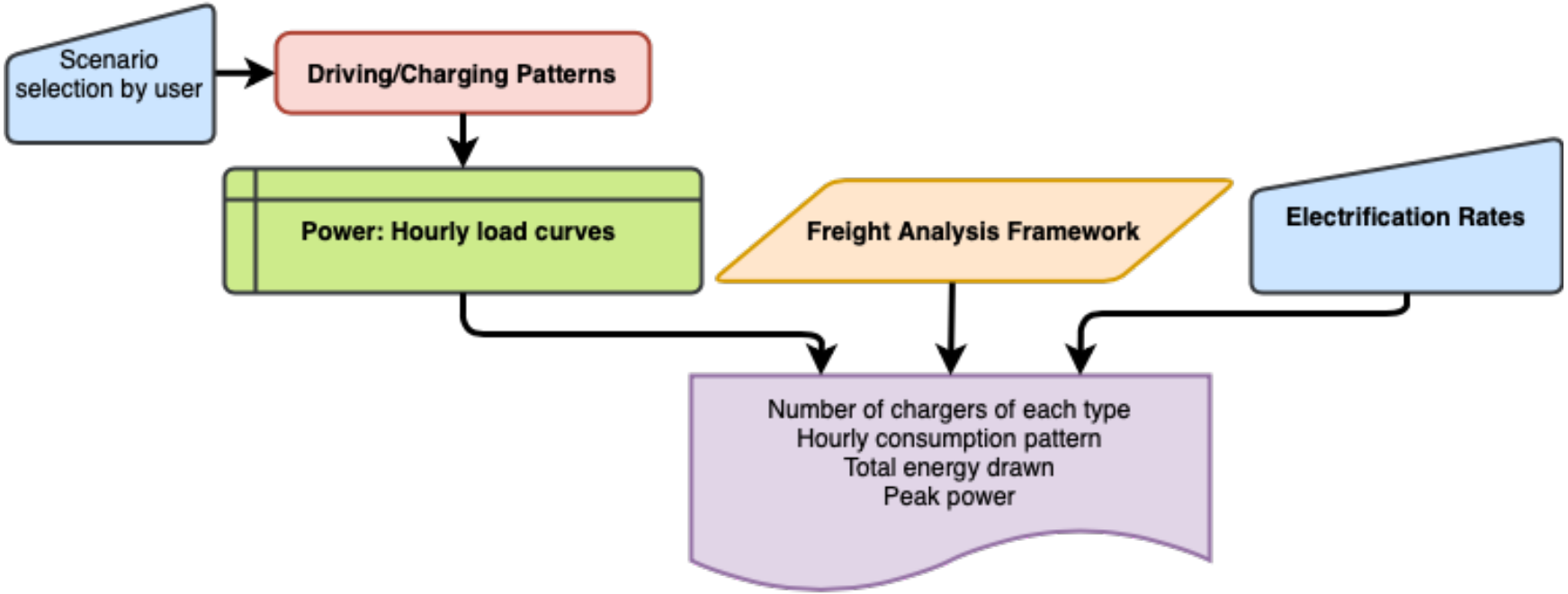
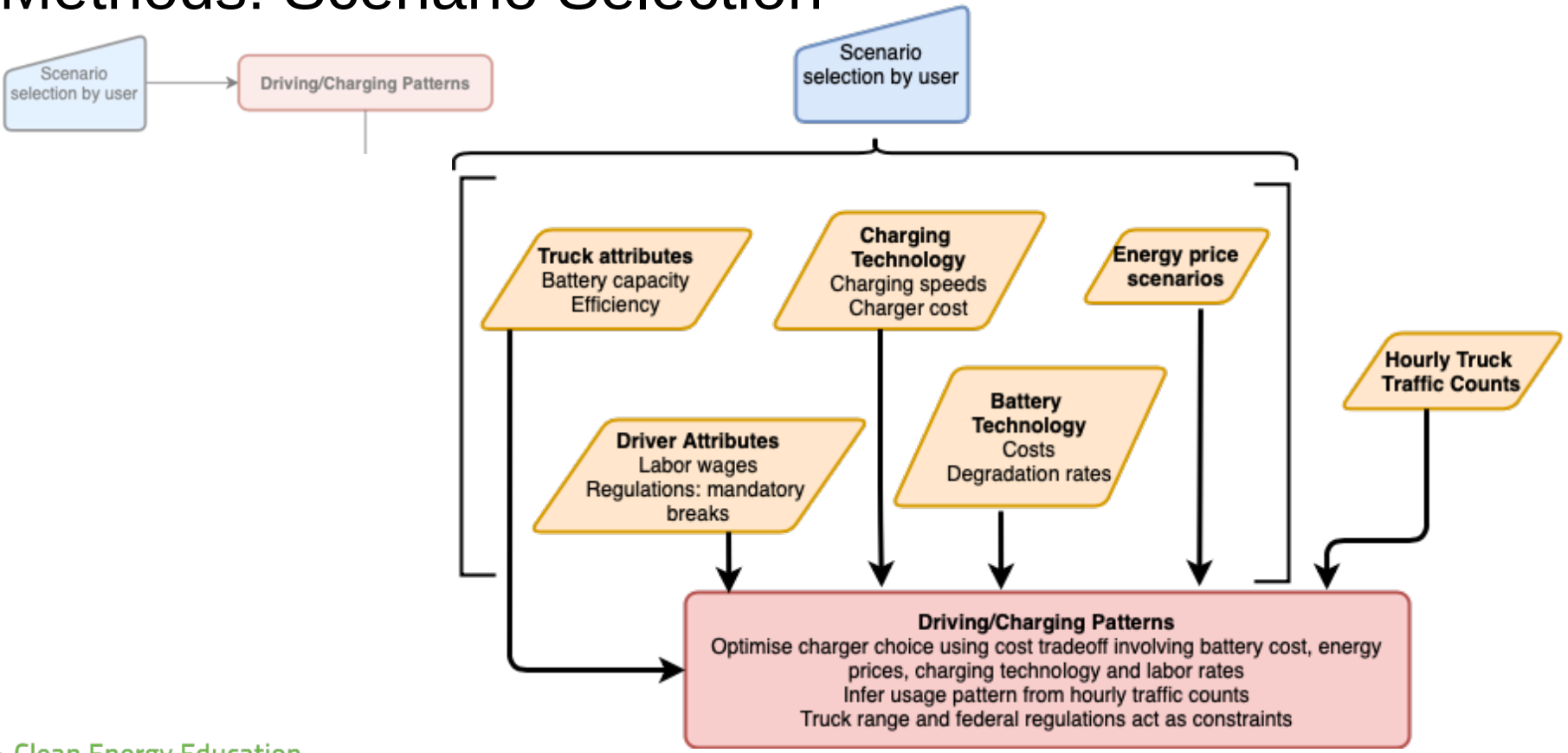
Methods


Scenario selection by user
Driving/Charging Patterns
Power: Hourly load curves
Freight Analysis Framework
Electrification Rates
Number of chargers of each type
Hourly consumption pattern
Total energy drawn
Peak power

Methods: Scenario Selection



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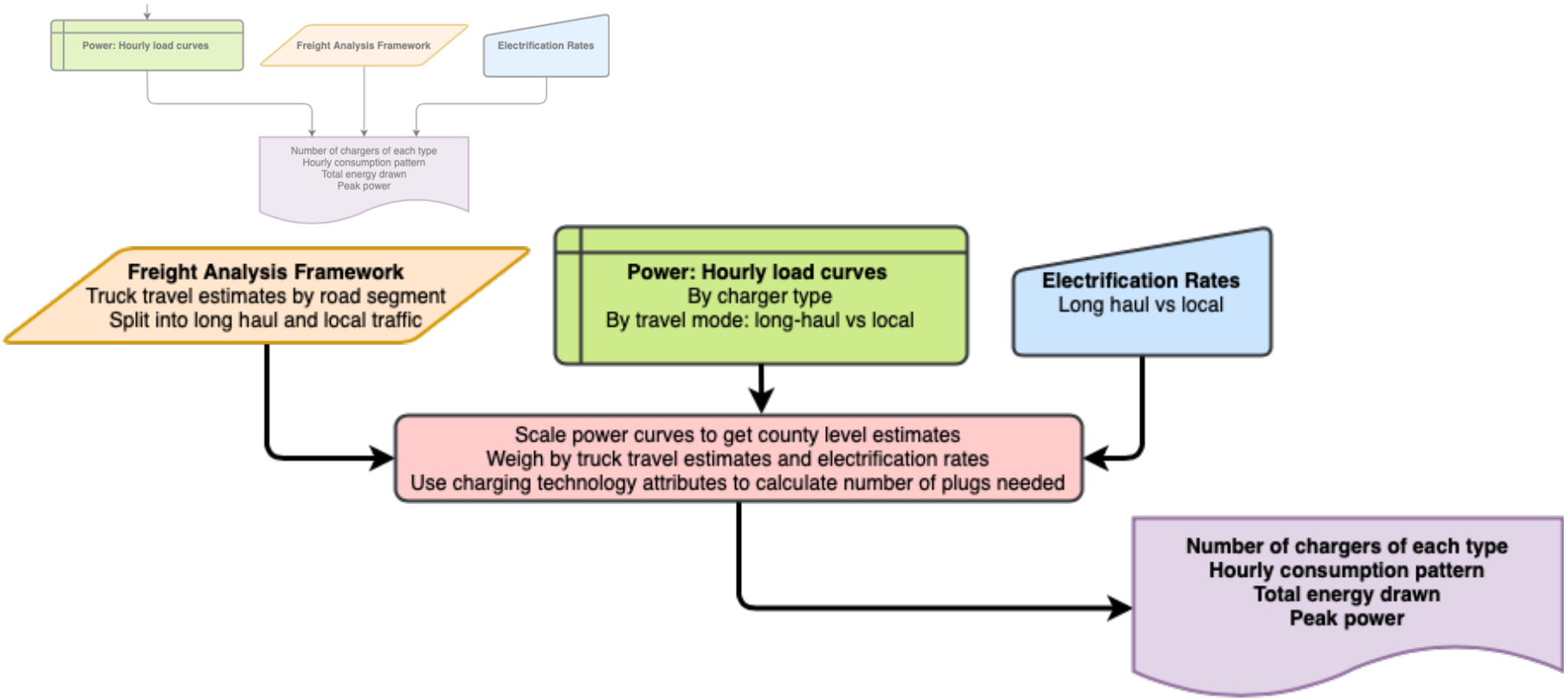
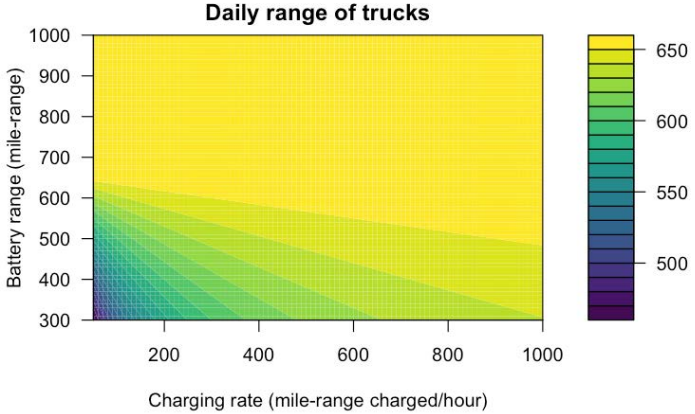
Methods: Analysis



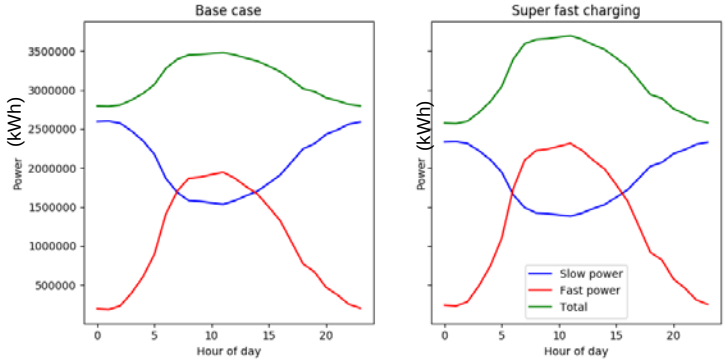
Results: Technological Needs

- Trucks can cover longer distances in a day if
  - Faster chargers are available
  - Battery capacity of trucks is high enough
- They are limited by regulations affecting work hours for truck drivers
- Faster and cheaper charging leads to usage during the day, as trucks can stop for short times to refuel
- Slow charging is predominantly used for recharging during truck downtimes, and while parked at night

Distance that trucks can cover in a day, as a function of charging speed and battery capacity



The effect of truck range on power draw and charger usage



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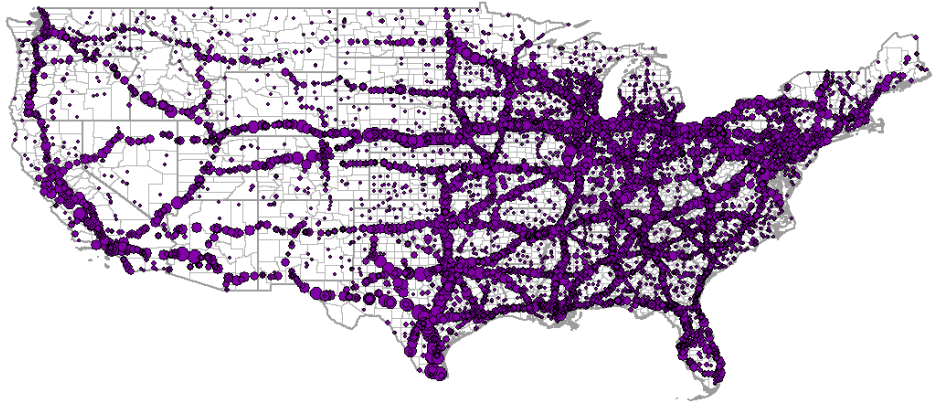
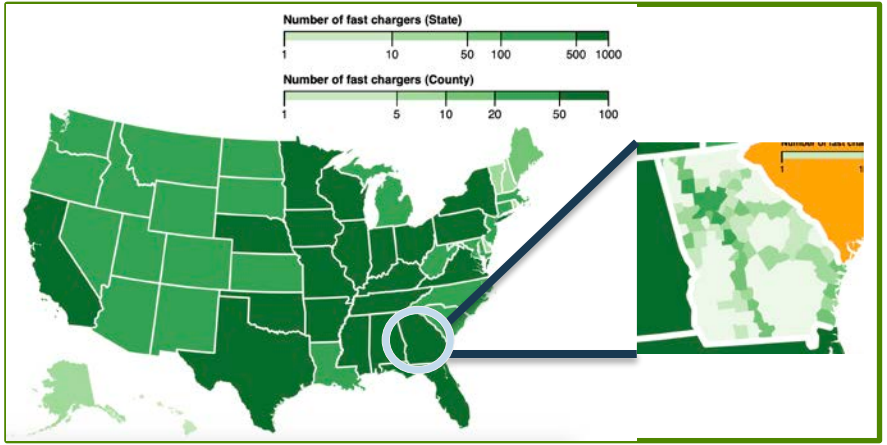
Results: Infrastructure Layout

- The charging station usage is impacted by
  - Truck range (battery capacity)
  - Availability of charging technology
- Usage coincides with high traffic regions, notably highways and city centers
- The number of chargers needed in each state depends on:
  - Truck traffic: presence of major highways and freight centers
  - The distribution of short haul and long-haul traffic

Truck stop charger usage for 500-mile range trucks



Fast charging infrastructure needed across the country, county and state level



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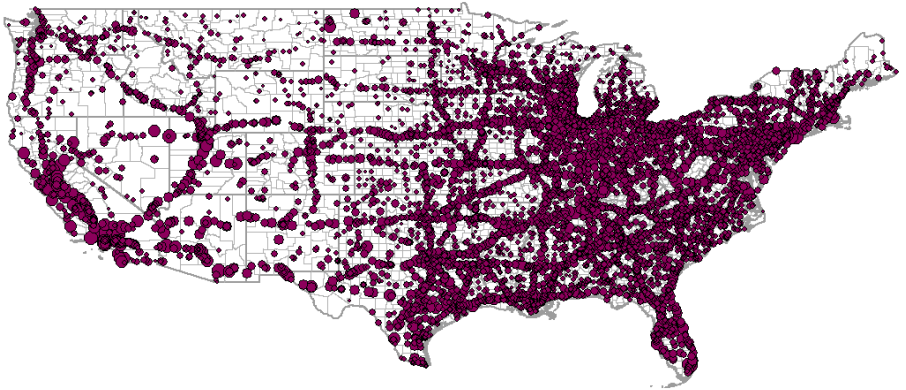
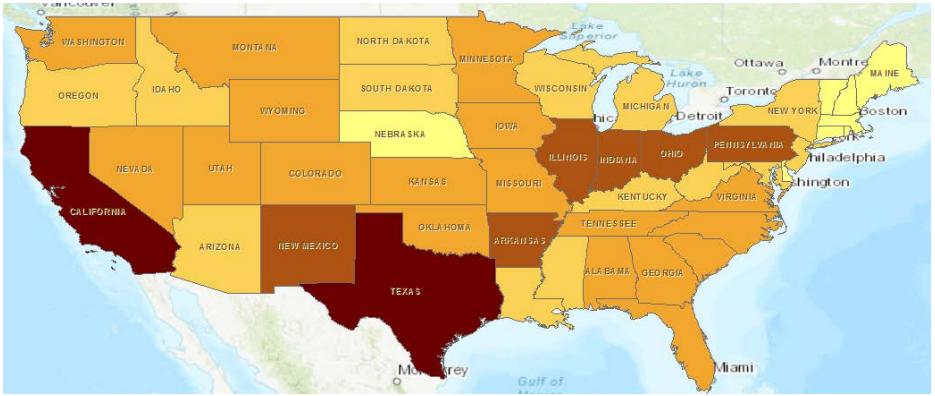
Results: Electric Grid Impacts

- Substations see a varying increase in load depending on traffic
- States can have load increases due to truck electrification of up to 20%, with an average 10% increase
- A limited network of optimally placed chargers can electrify all possible trips
- Availability of fast charging, and longer truck ranges are the two most important factors

Substation level load impacts



State level generation impacts



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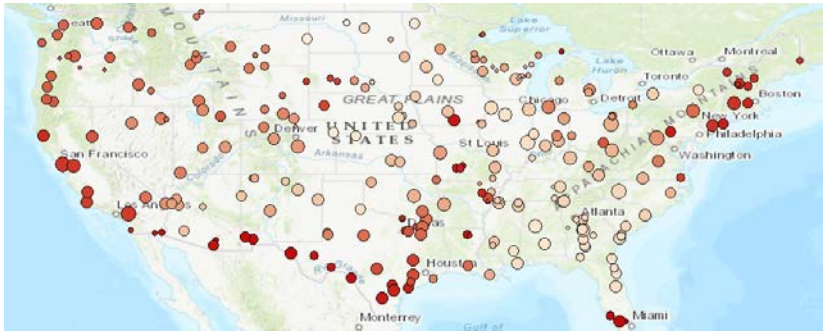
Conclusions

- Dramatically low electricity prices, much faster charging speeds, improved range, and developments in autonomous vehicles can potentially be leveraged to enable widespread and cost-effective adoption of electric trucks to deliver large economic and environmental benefits.

- The lack of timely deployment of appropriate charging infrastructure is likely to be a key barrier: prioritizing infrastructure outlay in a planned manner can help avoid upgrades

- There is a need to plan for futuristic technology to avoid future write-downs of infrastructure outlay.

- Impacts on the grid can be analyzed at a spatial level and planned for. Costly transmission upgrades can be avoided by locating charging stations optimally



Minimal charging network for 200-mile range trucks

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References

Data sources:

- Freight Analysis Framework: https://faf.ornl.gov/fafweb/
- NACFE reports:

  2018. *GUIDANCE REPORT: Electric Trucks Where They Make Sense*. North American Council for Freight Efficiency.

  2019. *More Regional Haul: An Opportunity for Trucking*? North American Council for Freight Efficiency.

  2019. *Amping Up: Charging Infrastructure for Electric Trucks.* North American Council for Freight Efficiency.
- Washington Traffic Recorders: https://www.wsdot.wa.gov/mapsdata/tools/trafficplanningtrends.htm
- Velocity Suite (proprietary data on energy prices at LMP nodes)

Algorithms/software:

- ArcGIS
- Greedy search