Addressing the 95% infrastructure challenge for electric transport

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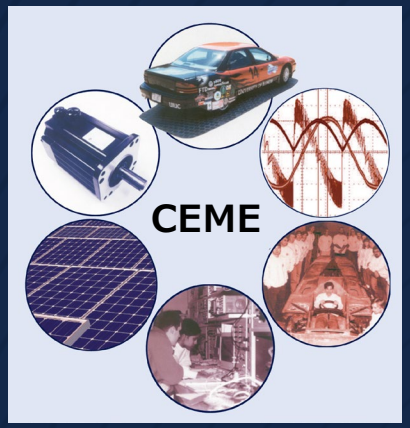

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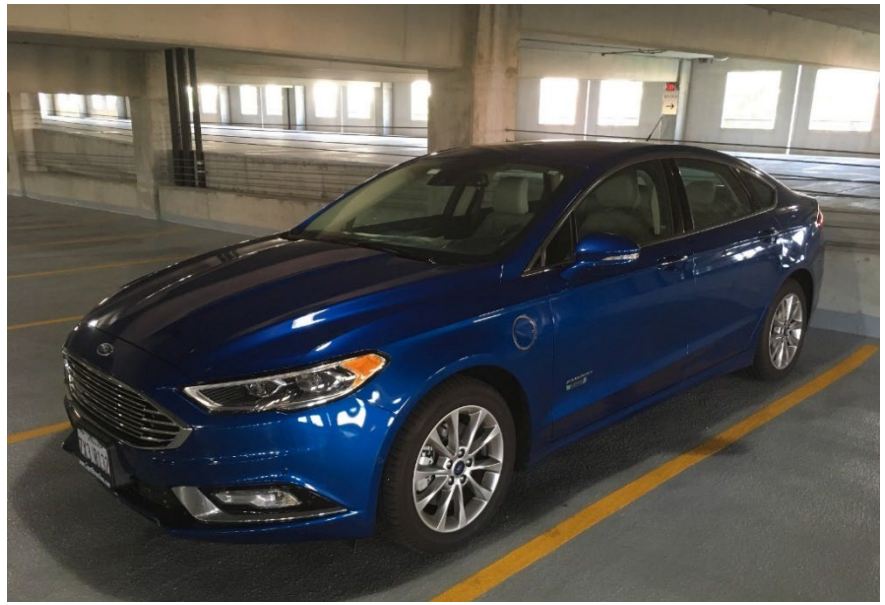
Why electric (and hybrid) vehicles?

- **Energy reduction and energy flexibility**
- **Emissions reduction, including carbon**
- **Opportunities for operation, control, autonomy**

These come with lower operating costs and high performance



People seem to overestimate costs of major transitions – and underestimate benefits

New York pollution impact

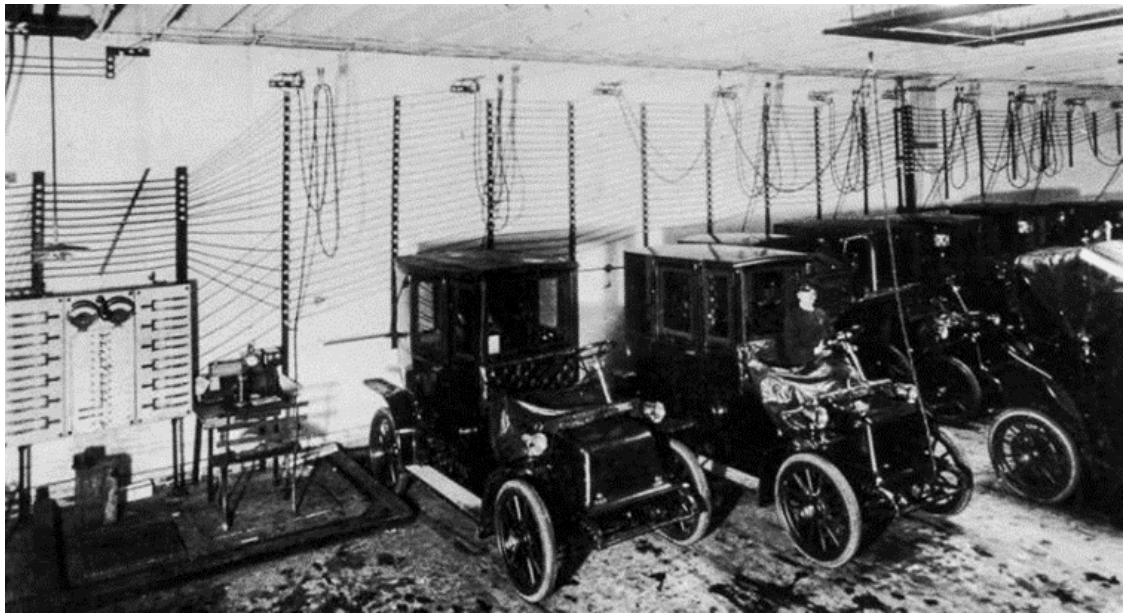
Manhattan skyline, May 1973: Chester Higgins, National Archives

Manhattan skyline, April 2021: wherearethosemorgans.com

Key fallacy

“An electric car will need to match everything we can do with a conventional [fueled] car.”

-- Fallacy because differentiation is common in transportation markets: no baseline
-- So far, EV owners do not use cars as they do fueled cars



http://easyway.site (Schenectady Museum of Innovation and Science)

Early EVs were treated to emulate horses!
This horse stable has been repurposed for EV charging.

What about charging infrastructure?

Charging infrastructure is a big barrier for plug-in vehicles.
Should we emulate fueled vehicles?

Safety and safety perception
Charge rates vs. connection and driver time

Can we just use regular outlets (for passenger cars)?

Cheap: retail electricity or less.

Courtesy of Alicia Tomaszewski

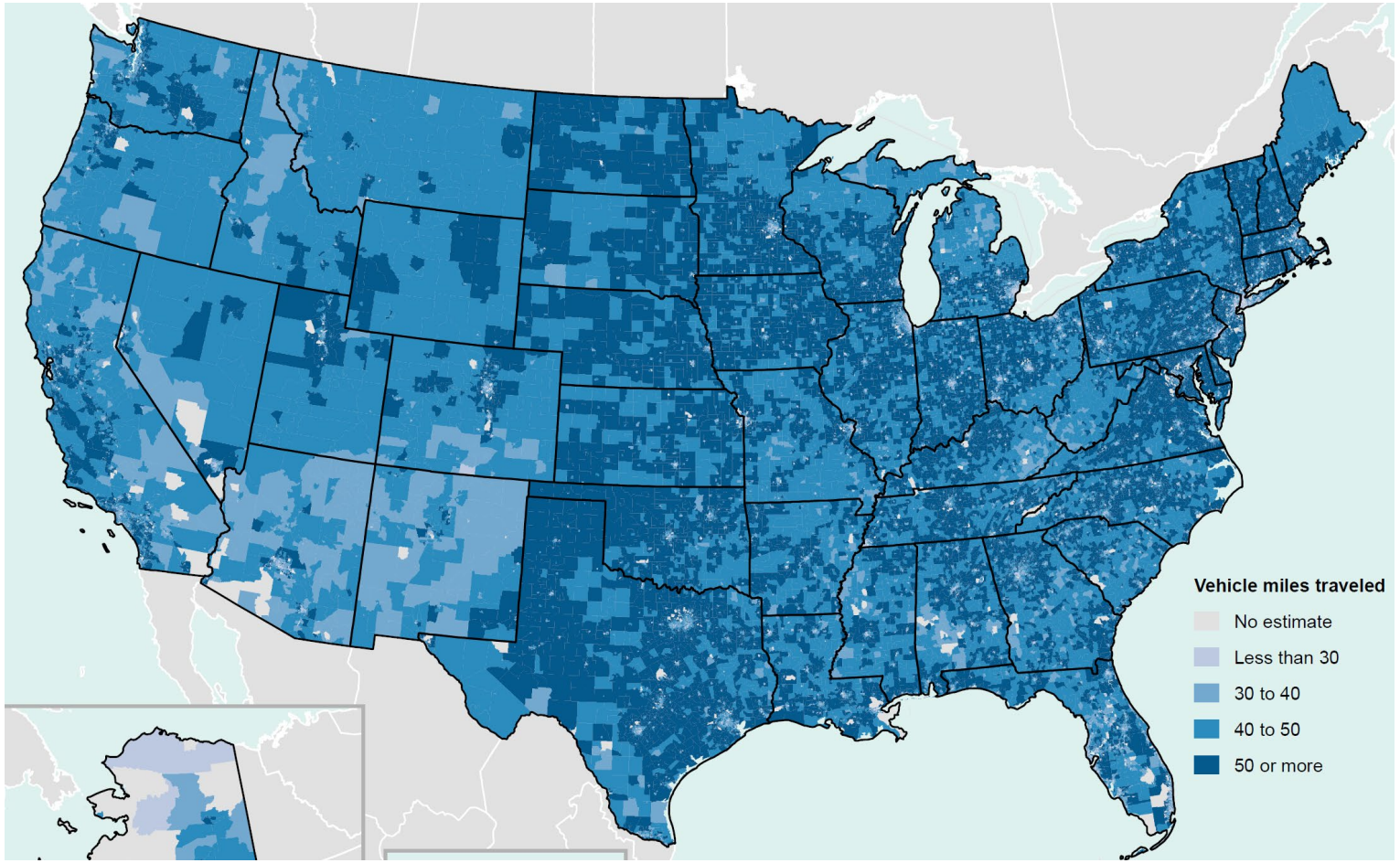
What is the 95% challenge?

U.S. daily car travel average is 29 miles.

Less than 5% of trips exceed 31 miles.

EV drivers seek out simplicity and convenience.

The 95% challenge: Find a direct and simple way to support daily driving needs.



[1]Bureau of Transportation Statistics, updated May 2017.
http://www.bts.gov/sites/bts.dot.gov/files/docs/browse-statistical-products-and-data/surveys/224066/vmtmap.pdf
[2]http://nhts.ornl.gov/vehicle-trips

How much infrastructure do we have? Do we need?

Usual view: Only a few places to charge (Whitehouse.gov reports 130,000 nationwide)

Instead, hundreds of millions of conventional receptacles can provide ready energy access.

This is not the right approach for long-distance driving, but simple outlets at home and work can support 95% of daily trips.

Some interesting conventional adaptations

In some places, infrastructure exists for adaptation

Block heater receptacles in Saskatchewan can become a forest of low-cost EV charge points. Linked to parking costs.

Regina.ctvnews.ca, used by permission

Entrepreneurs in Finland are repurposing block heater receptacles to provide 1 million EV charge points in a nation with 3 million cars.

www.inisideevs.com

Basic receptacles as infrastructure

Can a simple 120 V receptacle really support EVs?

-- Typical recharge rate is only about 5 miles per hour.
-- But passenger cars are parked many hours a day.
-- Support for 95% of daily trips is straightforward.

A tool outlet or international outlet is twice as fast.

What about faster charging?

Typical dedicated “Level 2” charging

Charge rate can be 25 miles per hour.
-- Still too slow for long distances.
-- For 95% of daily trips, not much benefit.

Campus survey:
Typical usage 8 hrs per month

Electrek.co, 2/18/2020

Expensive: Charger pricing must add a large premium above energy cost to cover installation and maintenance.

Fast charging is vital for trucks and long distance

Fast charging is essential, but is expected to deliver only a modest fraction of transportation energy.

The pricing, in energy terms, might approach fuel energy prices.

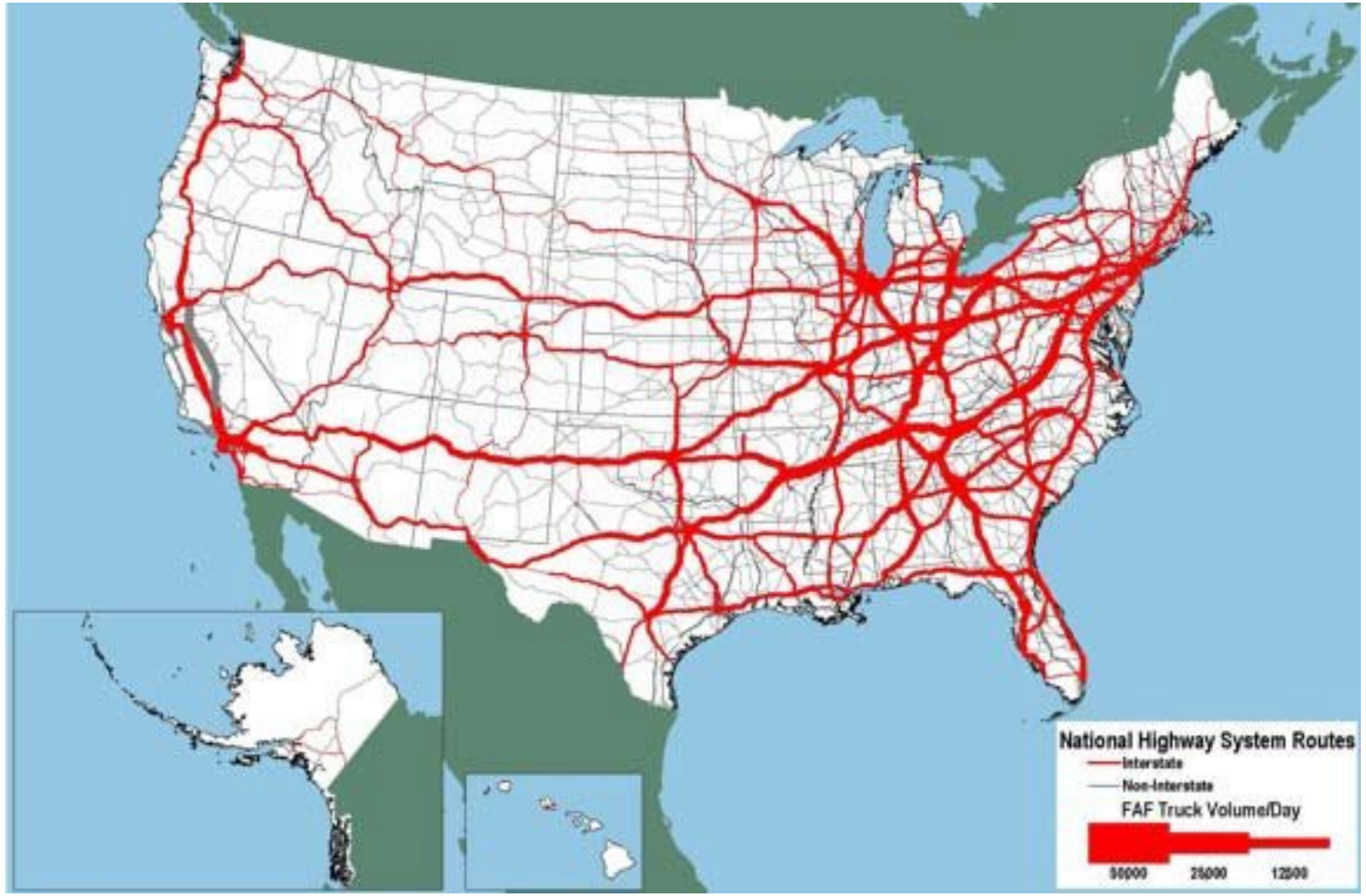
www.loves.com

Location planning is important for fast charging

Truck volumes on U.S. highways, 2017

This map provides insights about locating fast charging.

It also suggests possible plans for *highway* electrification.



US Department of Transportation

Basic scenarios in a small Midwest town

-- Employees, residents park several hours per day.
-- Visitors seek to shop and dine, parking for a few hours.
-- Short visit, dine or run errand, park about an hour.

Basic receptacles address employees and residents, lowest cost solution.

Parking meters and lampposts are an infrastructure opportunity.

Level 2 charging is nice for shorter visits. Compare energy cost to parking cost. *Energy overpricing is typical today.*

Unlimited range of business models for basic receptacles

1. Driver/EV pays.
   a) Roll into parking costs in a lot or at a meter.
   b) Local monthly or annual permit.
   c) Phone app to turn on outlet on and pay.
   d) “Roaming billing” for vehicle energy use.

2. Premises/location pays.
   a) Offer energy as a service at a business.
   b) Point-of-sale activation: Energy provided to confirmed customers.
   c) Charging as an incentive in urban or small-town shopping districts.
   d) Link to solar canopies or similar resources.

The 95th percentile is about 9 kWh per day – about $1 per day for energy at retail.

A future orientation

We know where we need to be, well before 2040

-- Receptacles easily available at home, at work, while shopping.
-- Fast charge infrastructure in strategic locations to support long distances.
-- Communications, billing, coordination to make this work.

Work backwards to 2023 and accomplish this

-- Communications.
-- Safety.
-- Reliability.
-- Easy access!

Next steps

-- Safety-grade outlets
with network-ready switches.
-- Communication solutions.

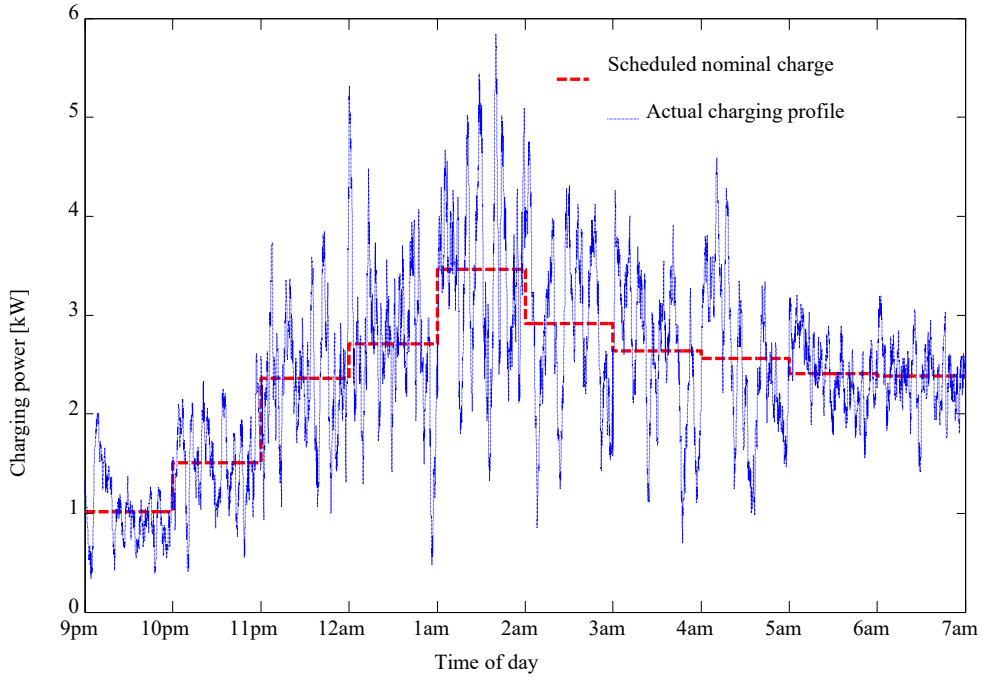
Courtesy of Yi Zhang

A connected car is a flexible car

This pair of plots compares two flexibility scenarios:

1. (Dashed line) Car controls low-cost charge.
- **a) Target time and amount of energy.**
- **b) Car downloads hour-by-hour prices.**
- **c) Minimize retail energy cost subject to limits.**

2. (Thin line) Grid operator controls low-cost charge.
- **a) Target time and amount of energy.**
- **b) Grid makes adjustments every few seconds for dynamic regulation services.**
- **c) Additional energy discount to car owner.**



M. A. Fasugba and P. T. Krein, "Cost benefits and vehicle-to-grid regulation services of unidirectional charging of electric vehicles," in *Proc. IEEE ECCE*, 2011, pp. 827-834.

Some end points

95% of daily passenger vehicle trips can be supported from basic receptacles

Trucking is different, and needs to be addressed with location strategies. These also support distance driving.

Vast expansion of receptacle access in places where people live and work can support rapid scale-up of passenger car electrification.

Thank you to the interdisciplinary MARTEC team at Illinois.

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