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PEVs, Charging Corridors, and DOE Analysis

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Overview: Provocative Questions

- General Background: Why Analysis? Why EVs?
- Specific Background: Why Corridors?
- Corridor Analysis: How to Optimize?
  - Theoretical
  - Empirical
- Conclusion: Future Relevant DOE Analyses(?)

General Background: What is VTO Analysis?

Models and Tools:

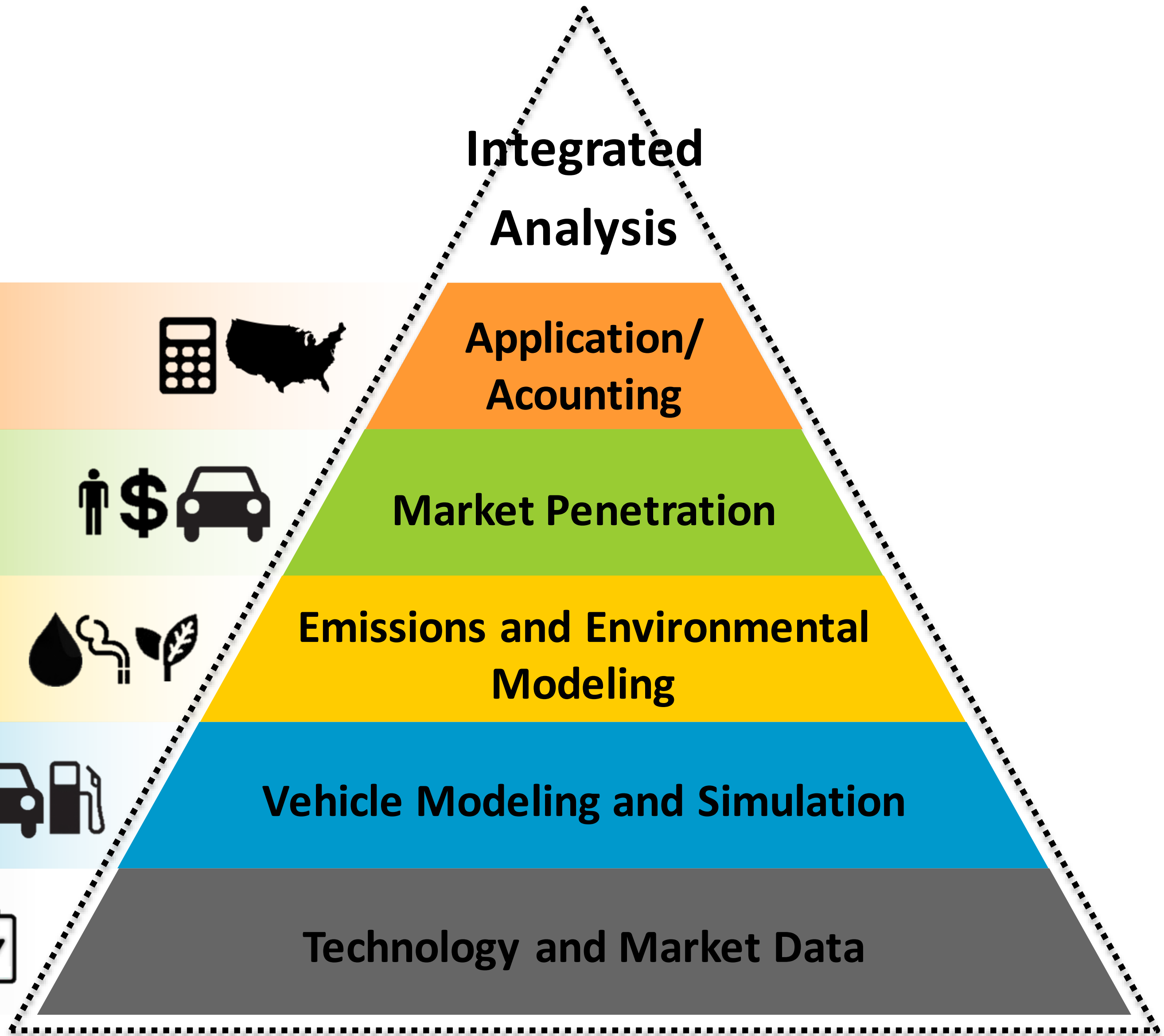
VISION, NEAT

ADOPT, LVC*Flex*, MA^{3}T, ParaChoice, LAVE-Trans

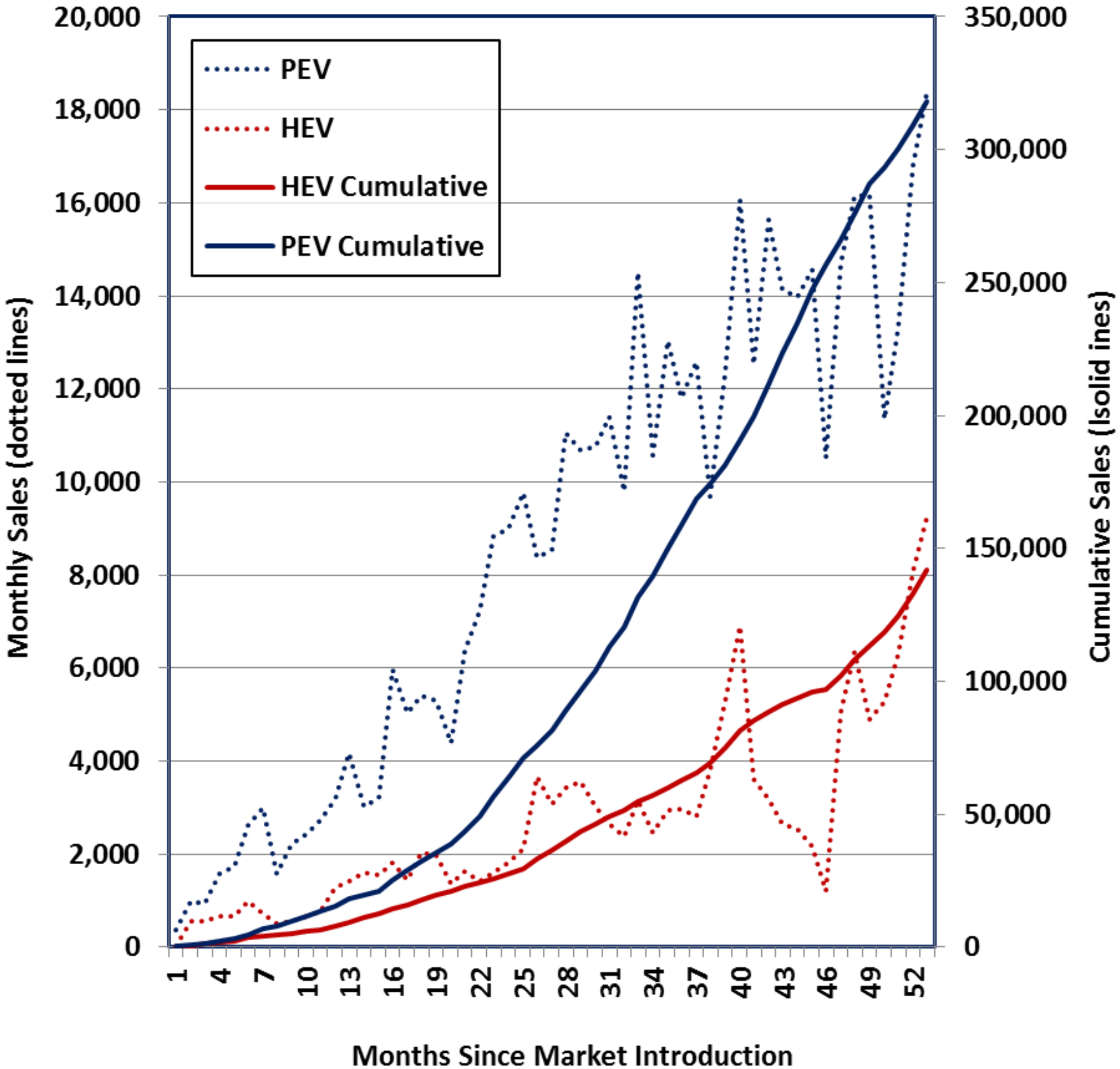
GREET

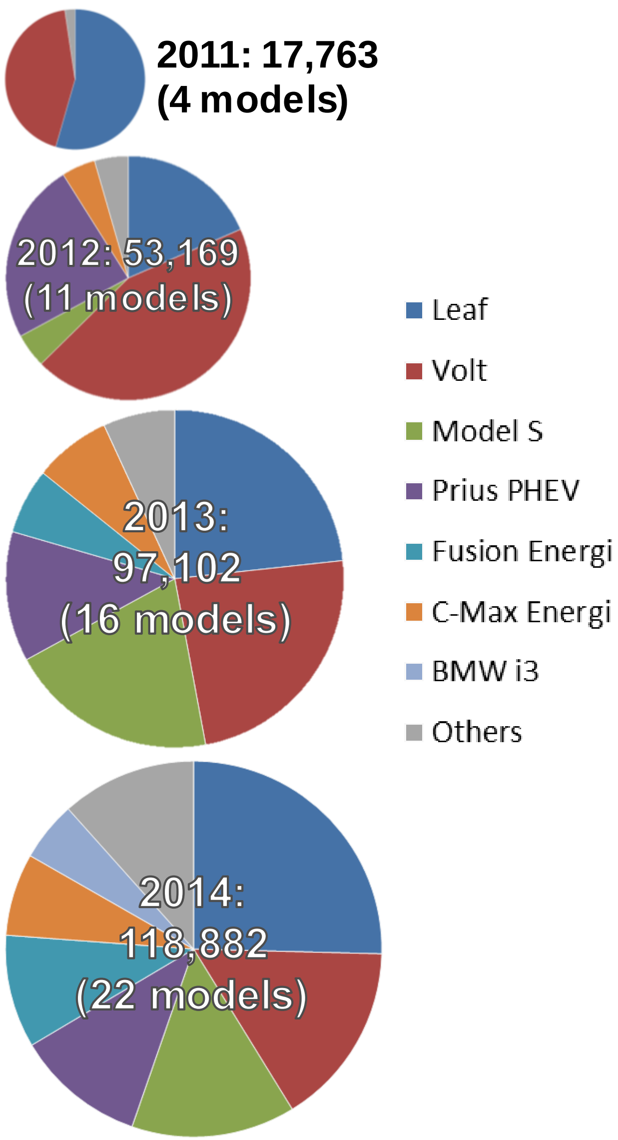
Autonomie, FASTSim
HTEB

TEDB, Market Report
xEV data, TREND



General Background: What are P/H/EV market trends?





DATA

Source: Zhou (2015), ANL.

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Specific background: Why corridors?

Travel surveys indicate corridor driving is an important portion of overall VMT:

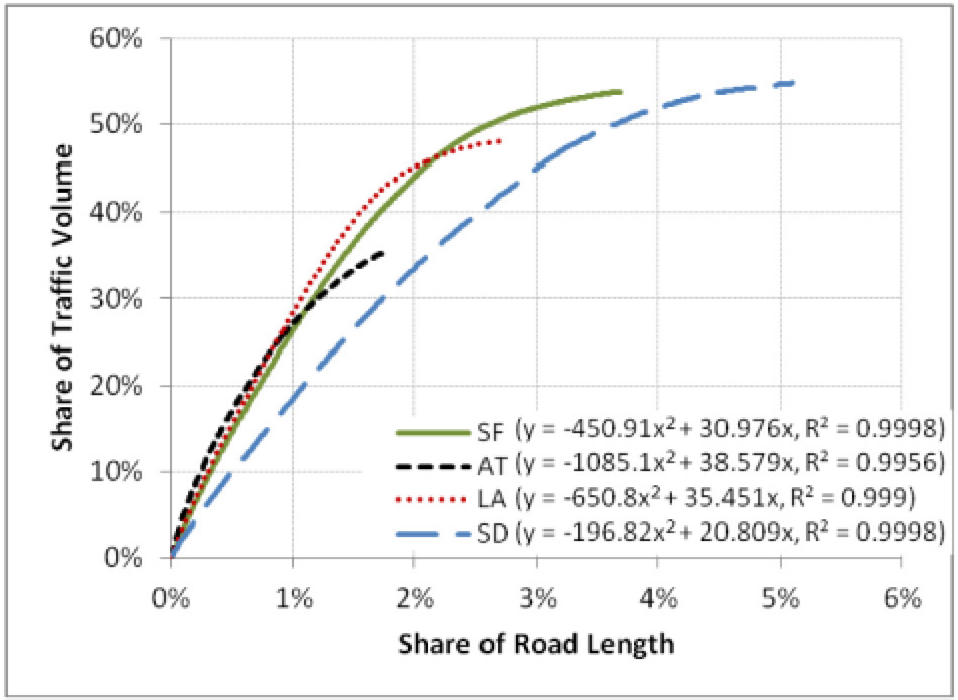
- Nationally, ~20% of driving is inter-city
- In Atlanta, only 7.5% of vehicles did NOT leave the metro area in one year’s time
  - Daily miles for out of metro area travel in Atlanta were considerably higher than estimated in NHTS (one-day sample)

Specific background: Corridors offer high-traffic benefits

High-traffic areas offer instructive correlations:
(even without knowing specific travel patterns)

High traffic (high-visibility, high-awareness) areas mean *charger opportunity*:

- Seeing,
- Wanting to see,
- Remembering, and
- Accessing.

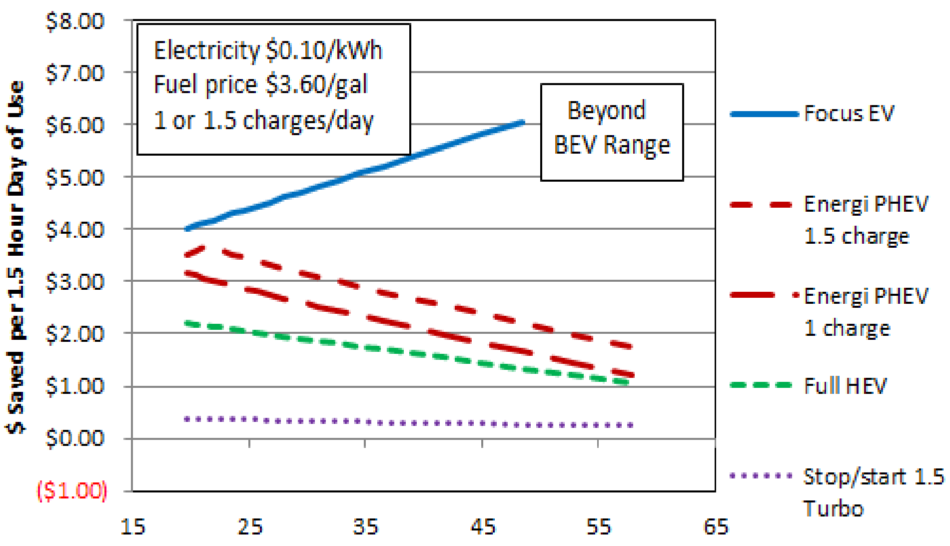


Only 3% of Road Length comprises 50% of Traffic Volume!

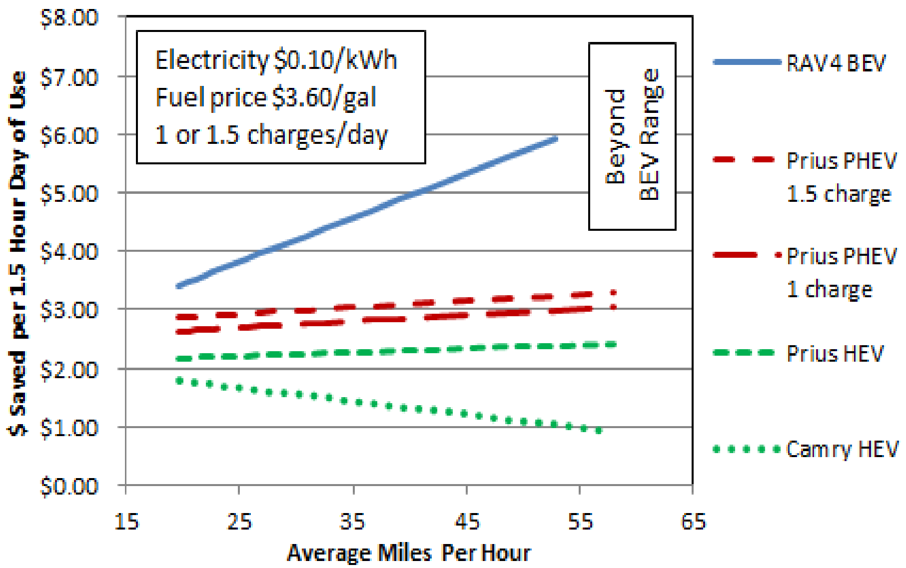
Source: Lin, Z., Li, J., and Dong, J., "Dynamic Wireless Power Transfer: Potential Impact on Plug-in Electric Vehicle Adoption," SAE Technical Paper 2014-01-1965, 2014, doi:10.4271/2014-01-1965.

Specific background: EV savings in long-distance corridors

Corridors at higher speeds and longer daily distances maximize EV fuel, emission, and cost savings.



Ford Fusion (& Focus) **Options** (vs. 1.5 Turbo)



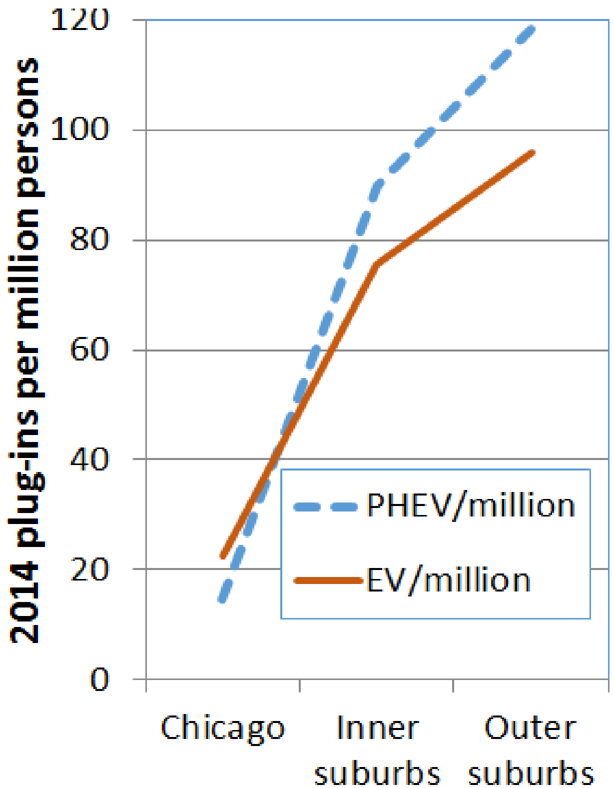
Toyota - Camry HEV, Prius and RAV4 EV vs. Camry 2.5

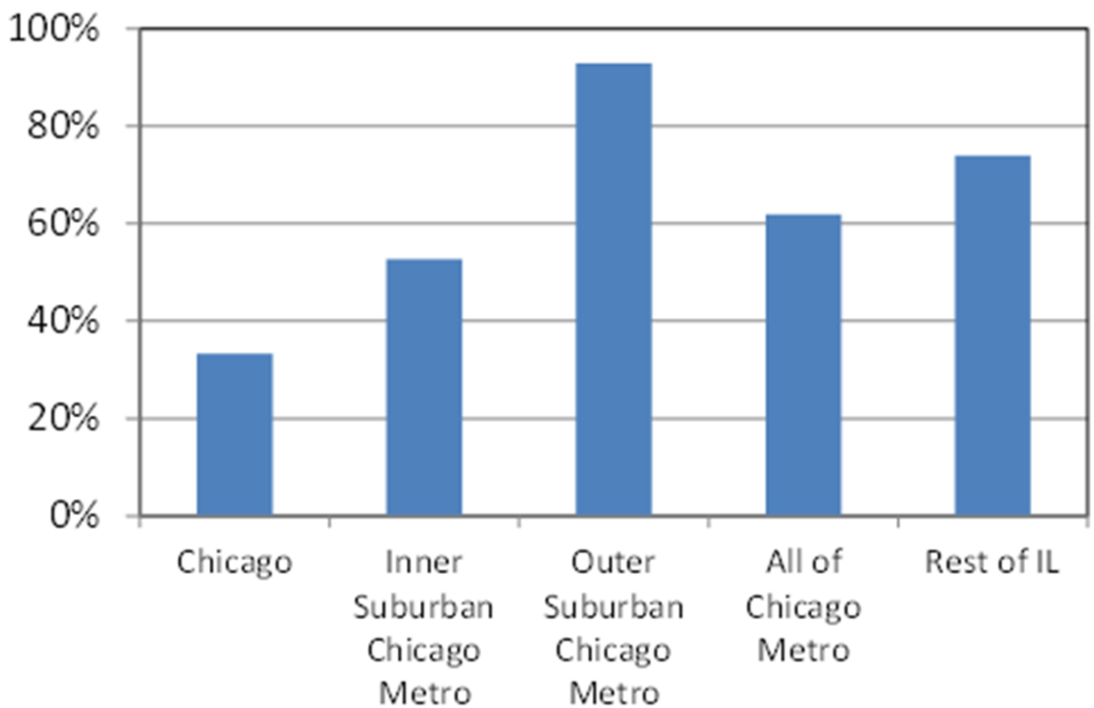
The positive slope of the blue line indicates increasing savings for BEV vehicles (Ford and Toyota vehicle offerings shown as examples) as a function of increased daily average speed.

Source: Zhou and Santini (2015), ANL.

Specific background: Sub/ex-urban EV sales and corridors

EV sales density increases away from city centers (left), but those consumers increasingly value range-extension (right).





Share of i3 REX models among all 2014 i3s registered

Source: Zhou and Santini (2015), ANL.

Specific background: "Worthwhile" vs. "urgent" charging

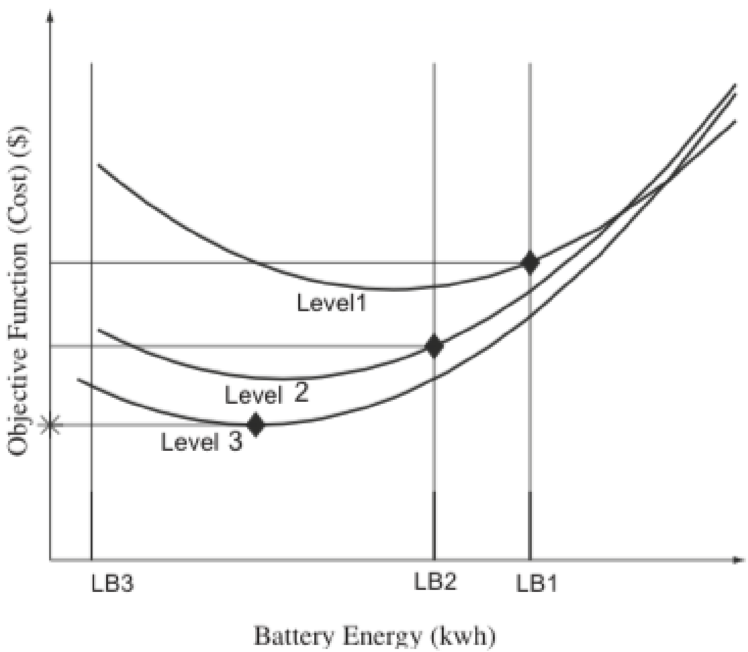
	Worthwhile charging	Urgent charging
Motivation for installation and/or use	• Convenient charging when stopping for other purposes (food, coffee, etc.) and find it *worthwhile* to plug in (SOC, charging power, available time, etc.)	• Necessary charging to finish otherwise non-stop (or otherwise impossible) trips *(Different than worthwhile charging!)*
Characteristic power and/or location	• Co-located with stores. Optimal charging speed as a function of parking time, user-friendly (wireless, weather-proof), optimal number of chargers for given consumer throughput	• High-speed charging. Strategic locations to match high-probability demand spots for urgency charging. *(Different than worthwhile charging!)*

Source: Lin and Greene (2011), ORNL.

Corridor analysis: a theoretical framework

Nie and Ghamami (2013) offer a corridor-centric optimization approach to planning electric vehicle charging infrastructure:

In this framework, "societal" optima fall at the minima of each curve; the "private" optima (the smallest batteries in each optimized system) are indicated by LB1–3.



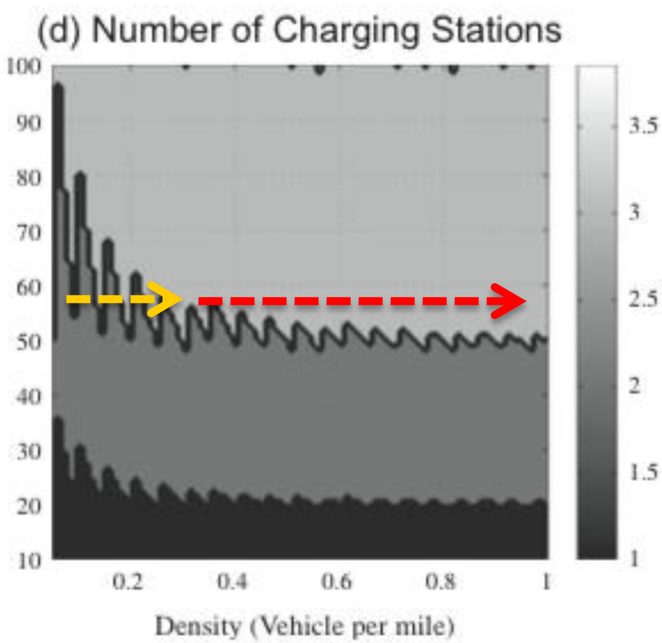
The authors conclude:

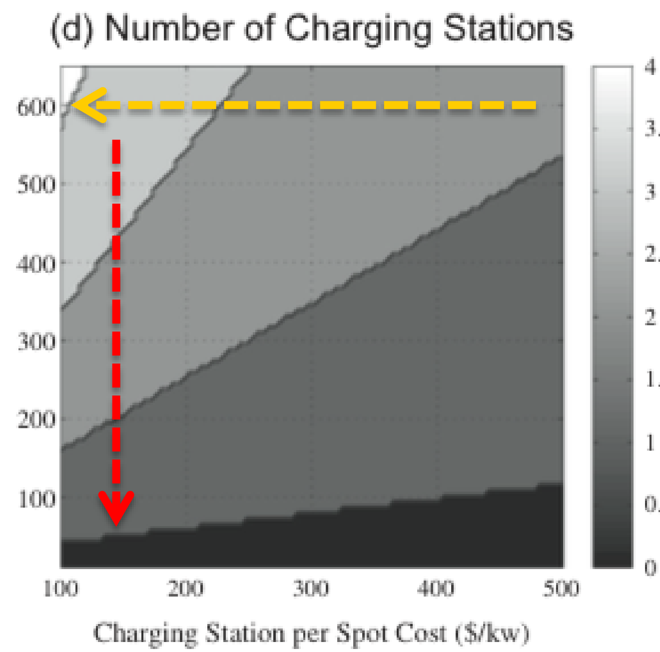
- Level 2 charging does not well serve traditional long-distance trips at high EV penetrations (though, it is socially optimal for low EV penetrations, which closely resembles the present reality).
- DCFC is needed to minimize the social cost, which can justify investment in fast charging to help EV adoption and reduced social cost through battery savings.
- Reducing the unit battery manufacturing cost offers larger benefits than reducing the unit charging power installation cost

Source: Yu (Marco) Nie, M. Ghamami / Transportation Research Part B 57 (2013) 172–190.

Corridor analysis: a theoretical framework

A theoretical framework can offer useful heuristics for planning electric vehicle charging infrastructure:





The optimal number of charging stations should increase as EV density increases—up to a point, after which the "optimal" number is steady.

The optimal number of charging stations should increase as charger technology cost decreases—but decrease as battery cost decreases.

Source: Yu (Marco) Nie, M. Ghamami / Transportation Research Part B 57 (2013) 172–190.

Corridor analysis: an empirical framework

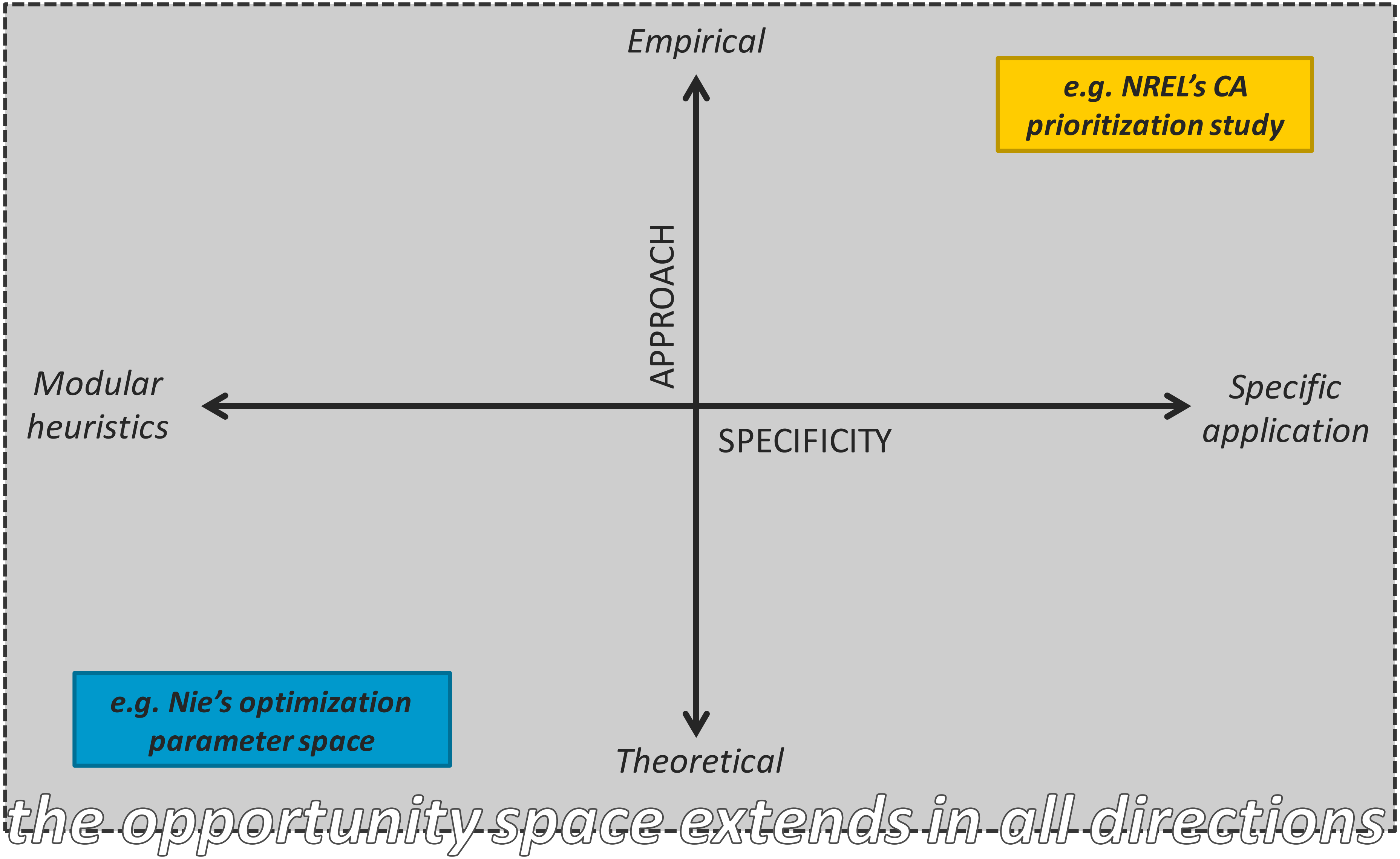
NREL collaboration with CA will prioritize corridors as a function of travel distance (VMT) and travel intensity (VMT/mi) data

Travel distance *(left) is a proxy indicator of likely need for recharge.*

Results of travel distance and travel intensity overlap suggest 6 priority corridors

Travel intensity *(left) is a proxy indicator for recharge visibility.*

Corridor analysis: a strategic framework



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Conclusions and observations: Future DOE analysis

In sum, analysis tools can offer context and understanding for corridors alignment with traffic intensity (and visibility), EV sales intensity, EV benefits-optimal usage patterns, and potential opportunities/benefits for EV charge.

Future DOE vehicle-infrastructure-related analyses include:

EV Everywhere

- EV National Economic Value Assessment (NREL)
- Modular Infrastructure Deep-Dive Analysis, with emphases on mid-size cities and EJZs (NREL)
- Commercial, Vocational, and Off-Highway EV Opportunity Analysis (ORNL)

< Both >

- Mobility and Freight Behavior/Decision Science and Application (LBNL)

SMART Mobility

- Vehicle-Infrastructure Alt Fuel Mobility Modeling (ANL)
- Connectivity, Automation, and Synergistic Benefits for Alternative Fuels (ANL, NREL, ORNL)

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EV Infrastructure Corridor Development Workshop

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