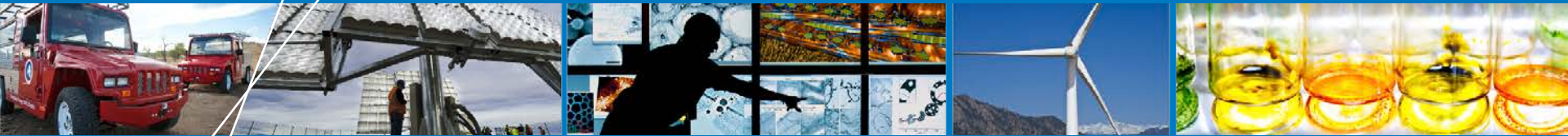# Geography of Existing and Potential Alternative Fuel Markets in the United States

Caley Johnson and Dylan Hettinger

Clean Cities Webinar

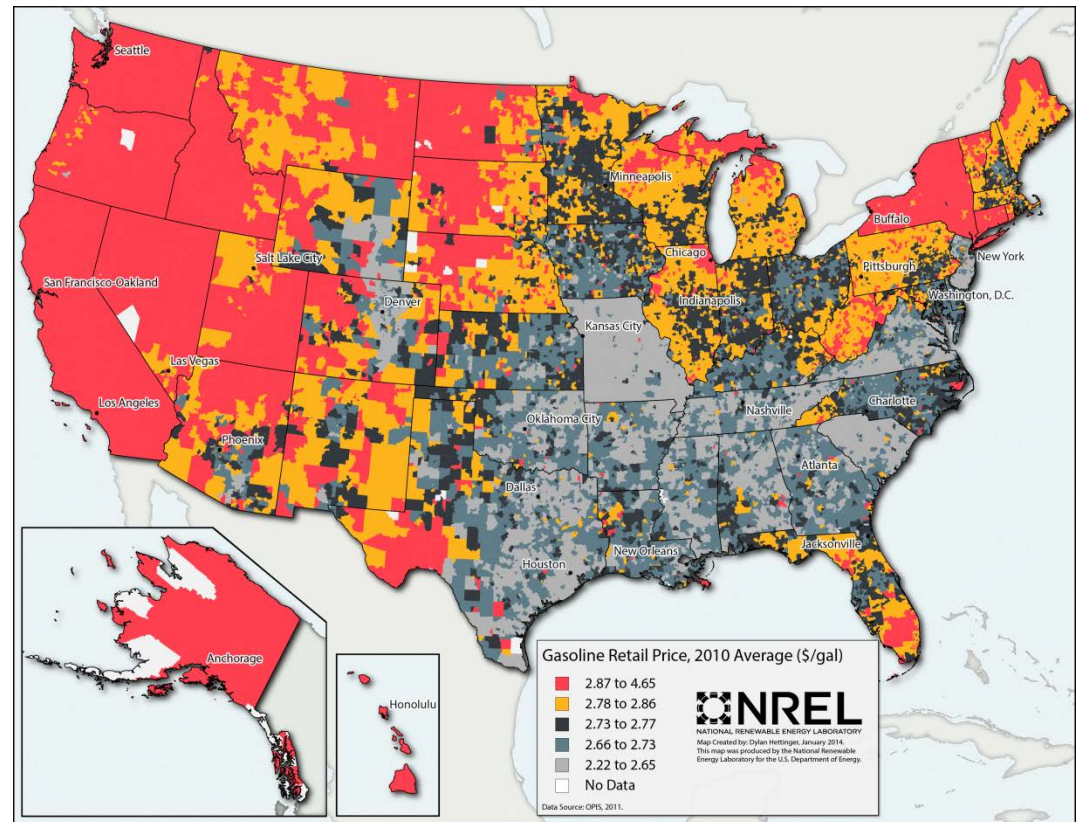**2/18/15**

Project Overview

- **Purpose**
  - To map the relative market strength (supply and demand) for CNG, Electricity, E85, B20, Propane, and associated vehicles
  - To prioritize and convey what the most important market indicators are when a stakeholder is choosing an alternative fuel
  - Derive lessons learned from unexpected markets
- **Process**
  - Weight market indicators based on literature and methodology
  - Fuel-specific adjustments based on industry experts' review of the maps
  - Determine best markets and investigate unexpected results
- **Audience**
  - Clean Cities Coordinators
  - Local/State Policymakers
  - Investors
    - Fleet Managers
    - Fuel Station Owners
  - Entrepreneurs
    - Vehicle manufacturers and dealerships

Indicators of Market Strength

1. **Existing Fueling Stations**
2. **Vehicle Density (including freight traffic and hybrids)**
3. **Gasoline and Diesel Prices**
4. **State Incentives**
5. **Resource Proximity**
6. **Environmental Benefit**

Gasoline prices by ZIP code.
Data source: OPIS 2011.

Gasoline Retail Price, 2010 Average ($/gal)
- 2.87 to 4.65
- 2.78 to 2.86
- 2.73 to 2.77
- 2.66 to 2.73
- 2.22 to 2.65
- No Data

Data Source: OPIS, 2011.

NREL — NATIONAL RENEWABLE ENERGY LABORATORY

Map Created by: Dylan Hettinger, January 2014.
This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.

Indicators not included

- **Household income: supplanted by AFV registrations**
- **Population density: supplanted by vehicle density and existing infrastructure**
- **Proportion of households with more than one vehicle: supplanted by AFV registrations**
- **Heavy-duty vehicle density: supplanted by freight ton-mile since Polk registrations are tied to headquarters, not garage or route**
- **Voting preferences: supplanted by policies promoting alternative fuels**
- **Commuting distance: need to find a sweet spot, since too short is bad (won't pay back AFV) and too long is bad (range anxiety)**
- **Average regional temperature: high temps improve battery performance but decrease battery life**
- **Education campaigns: too difficult to track and define regionally**

Weighting of Indicators

- **Starting with general prioritization**
- **All indicators reported as percentiles, combined and mapped**
- **Adjust to bring maps into agreement with industry experts**
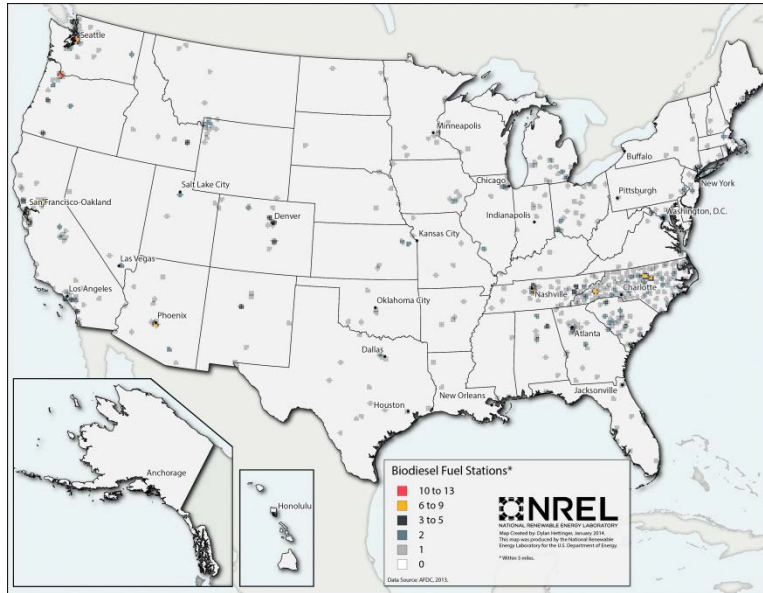- **Lessons learned from the changes in prioritization**

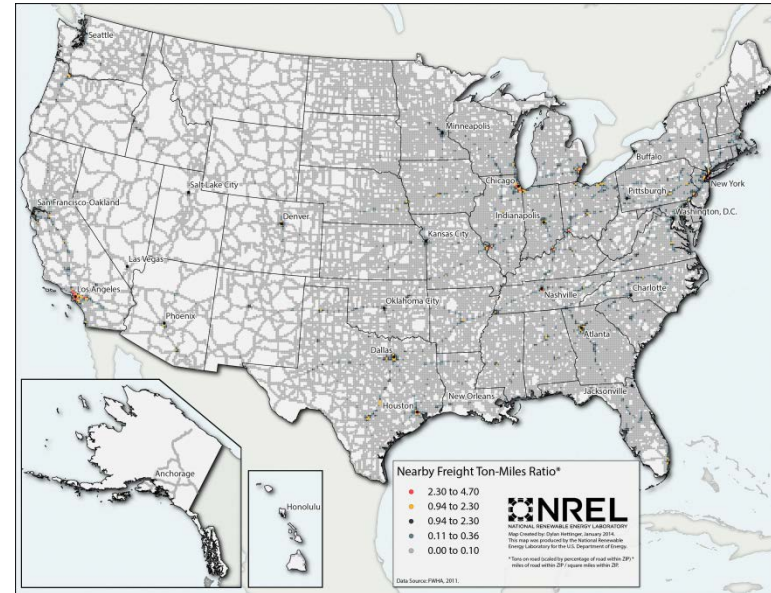| Fuel	Existing Infrastructure	Freight or HEVs	Vehicle Density	Gasoline/ Diesel Prices	State Incentives	Resource Proximity	Environmental Benefit
Electricity	19%	20%	16%	14%	10%	9%	12%
Biodiesel	24%	20%	16%	15%	13%	12%	—
Ethanol	30%	—	21%	10%	16%	23%	—
Natural Gas	34%	12%	11%	20%	15%	8%	—
Propane	32%	—	16%	19%	17%	16%	—
Average	28%	—	18%	16%	14%	14%	—

How Indicators are combined and mapped

1. Map broken into 10X10 km squares
2. All indicators reported as a percentile for that given square
   o Graded on a curve
3. Within each square, each indicator is weighted and added with each other for a combined score
4. Each square is grouped into a quintile based on combined score and colored accordingly
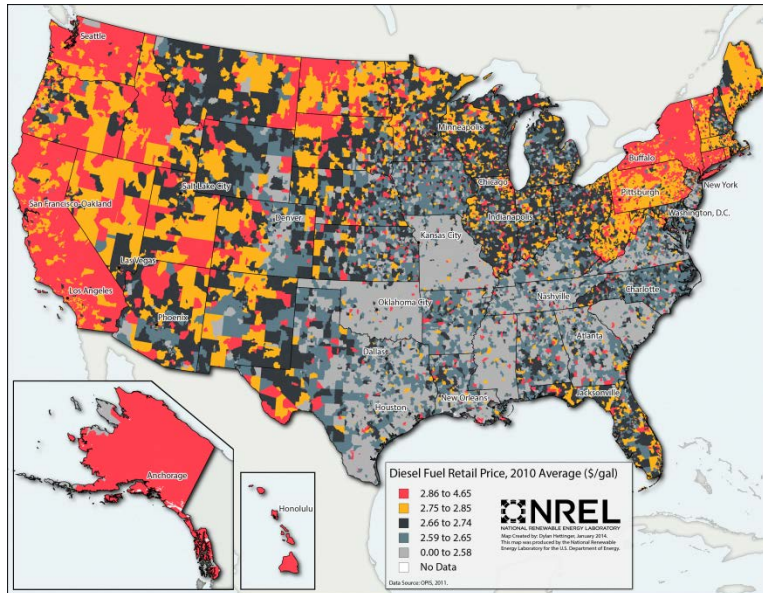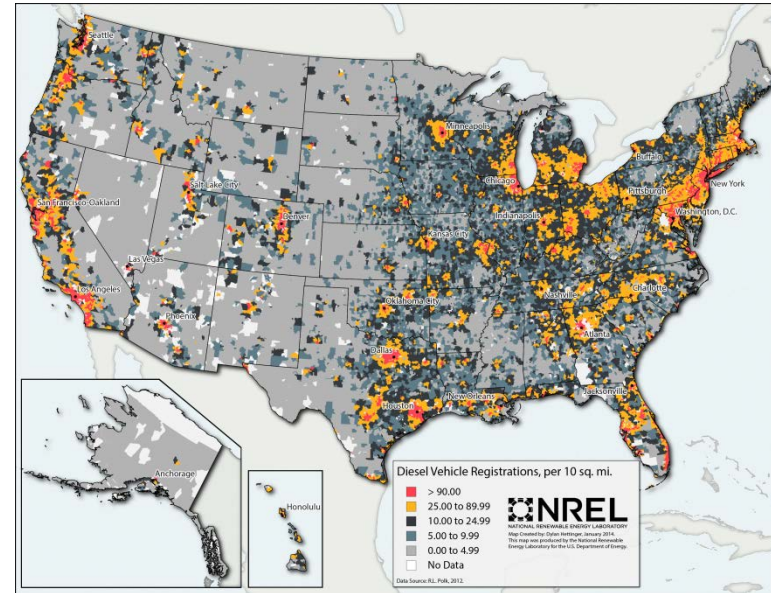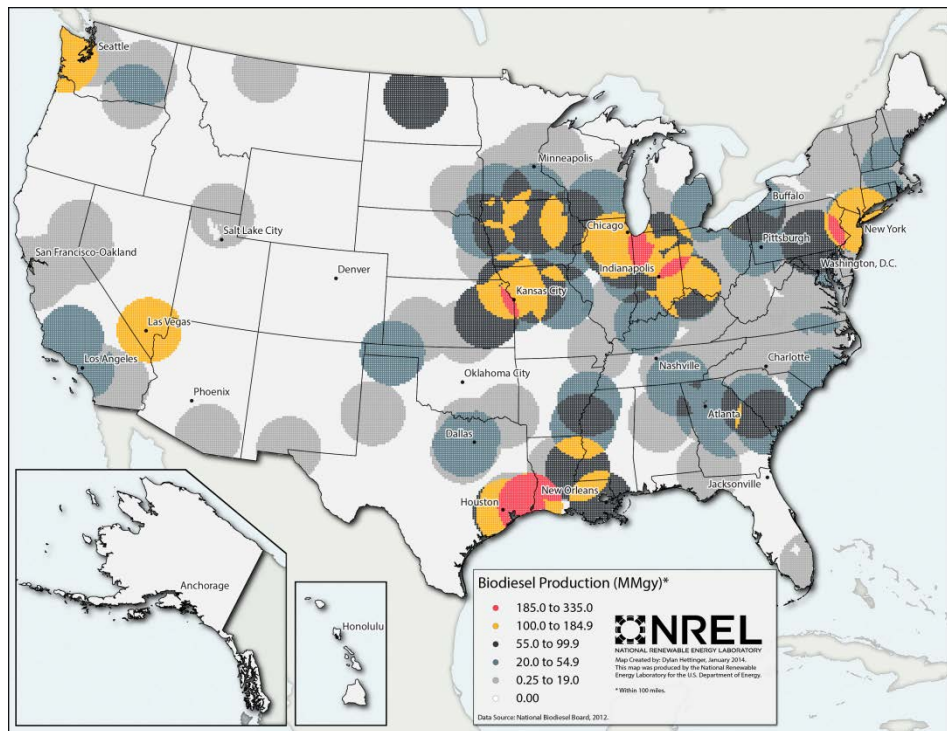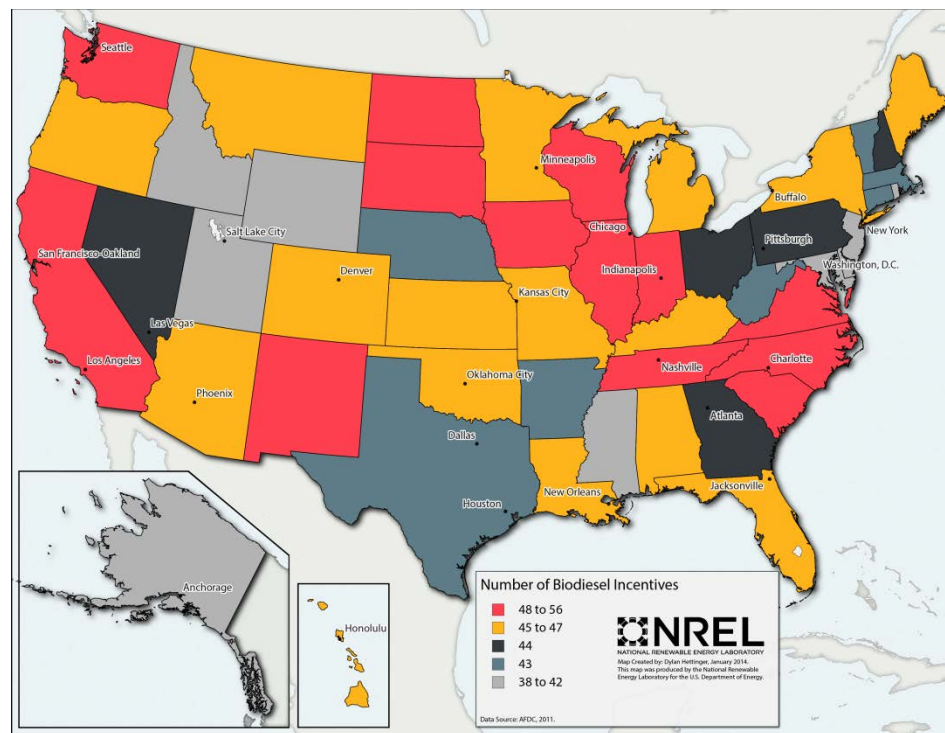
Biodiesel Components

24% — Biodiesel Fuel Stations*
- 10 to 13
- 6 to 9
- 3 to 5
- 2
- 1
- 0

20% — Nearby Freight Ton-Miles Ratio*
- 2.30 to 4.70
- 0.94 to 2.30
- 0.94 to 2.30
- 0.11 to 0.36
- 0.00 to 0.10

16% — Diesel Fuel Retail Price, 2010 Average ($/gal)
- 2.86 to 4.65
- 2.75 to 2.85
- 2.66 to 2.74
- 2.59 to 2.65
- 0.00 to 2.58
- No Data

15% — Diesel Vehicle Registrations, per 10 sq. mi.
- > 90.00
- 25.00 to 89.99
- 10.00 to 24.99
- 5.00 to 9.99
- 0.00 to 4.99
- No Data

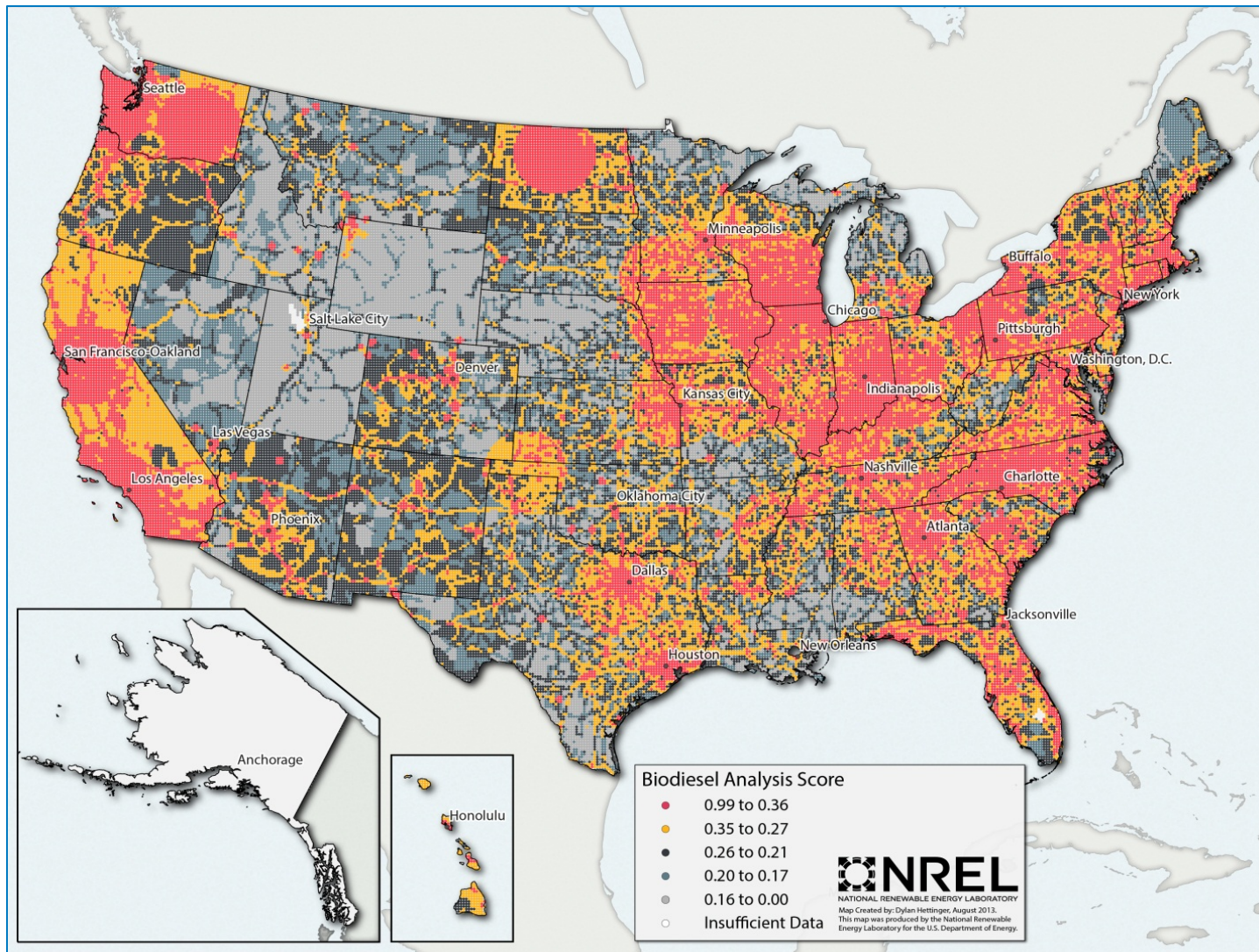# Biodiesel Components, *continued*
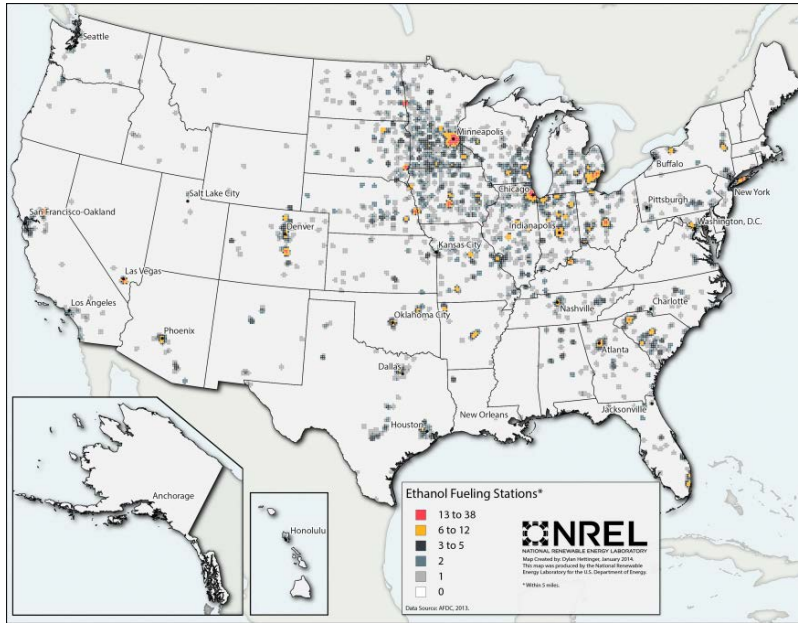

13%

12%
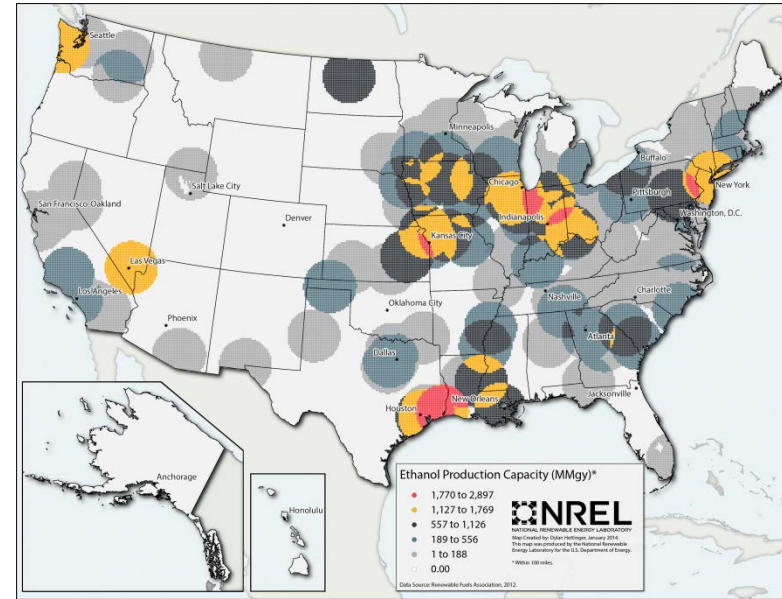
Biodiesel Markets

Map of the most active vehicle biodiesel markets

Ethanol Components

30%

23%

21%
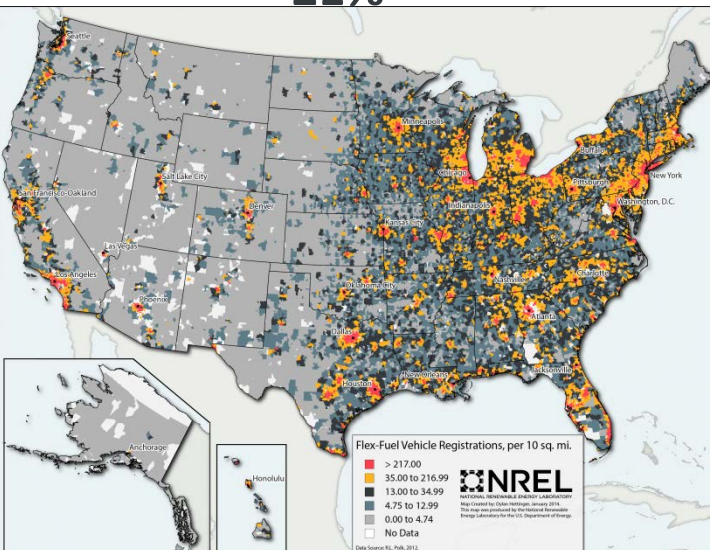
16%

10%

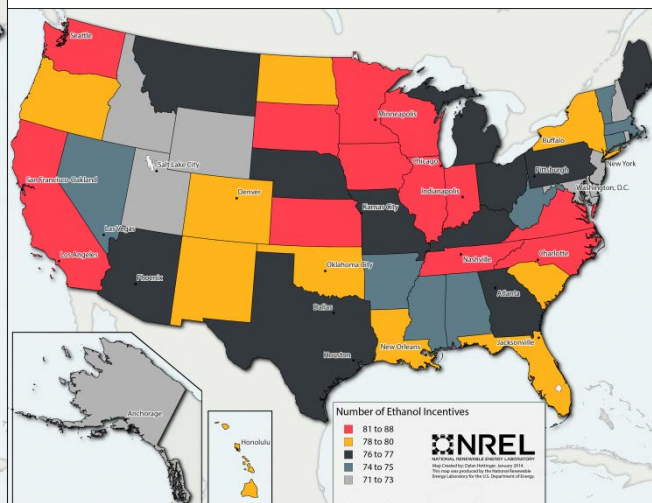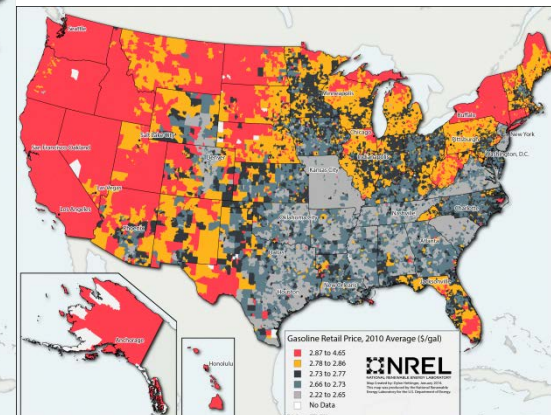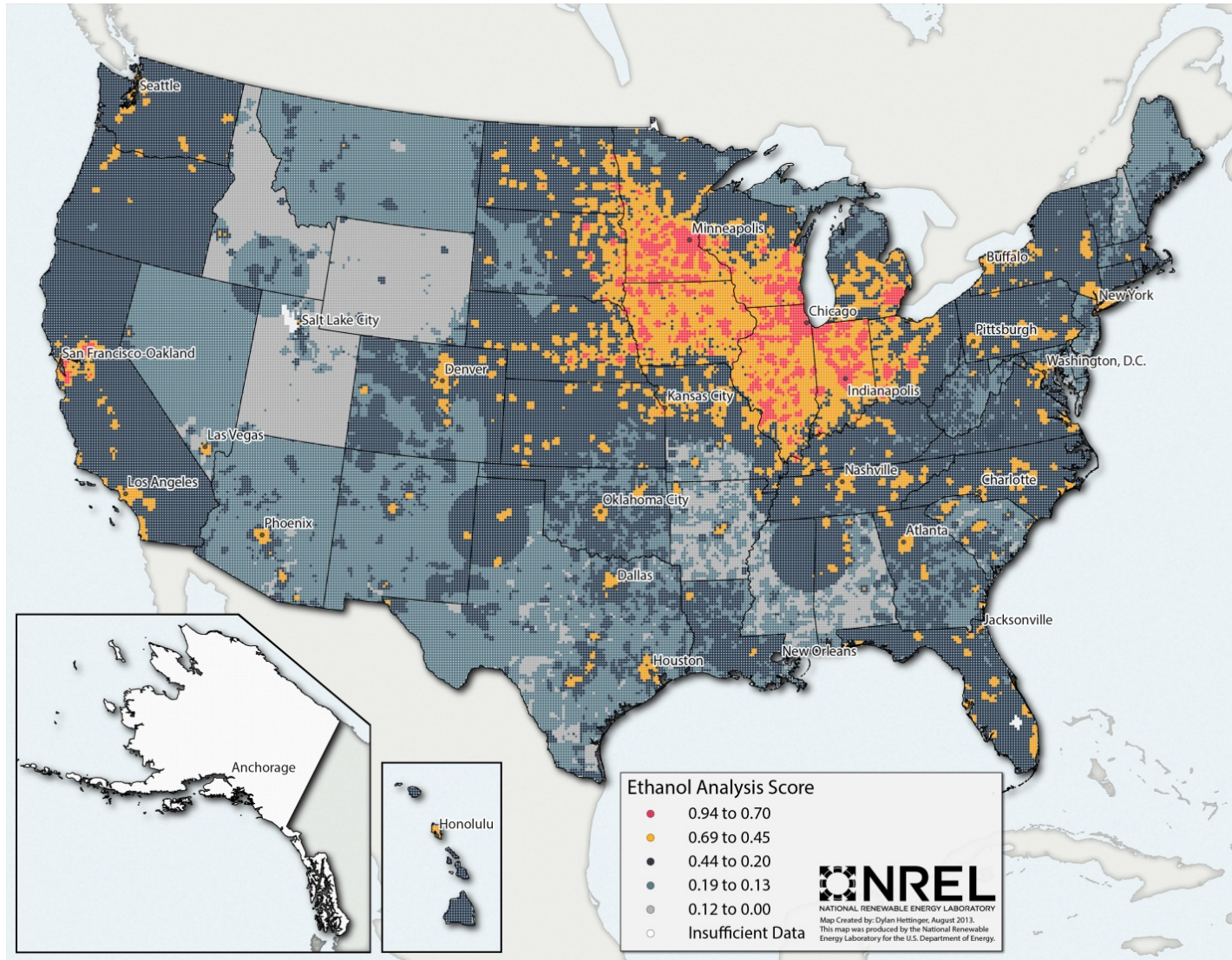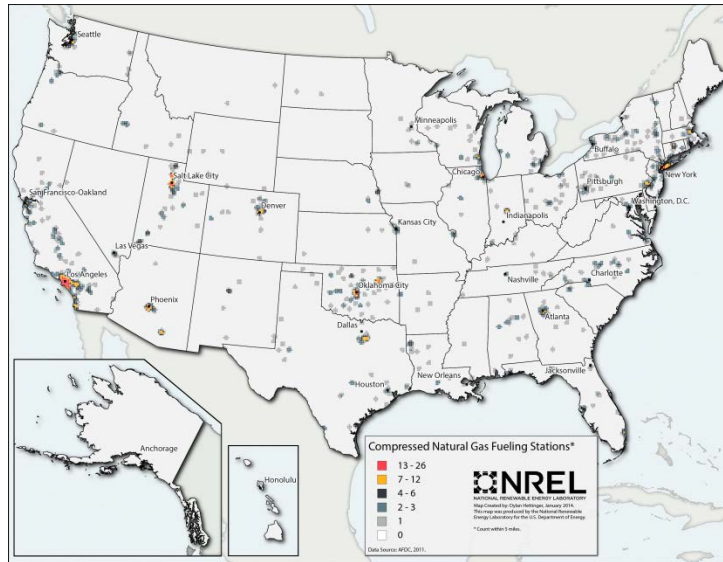# Ethanol Markets

Map of the most active E85 markets

Compressed Natural Gas Components

34%

20%
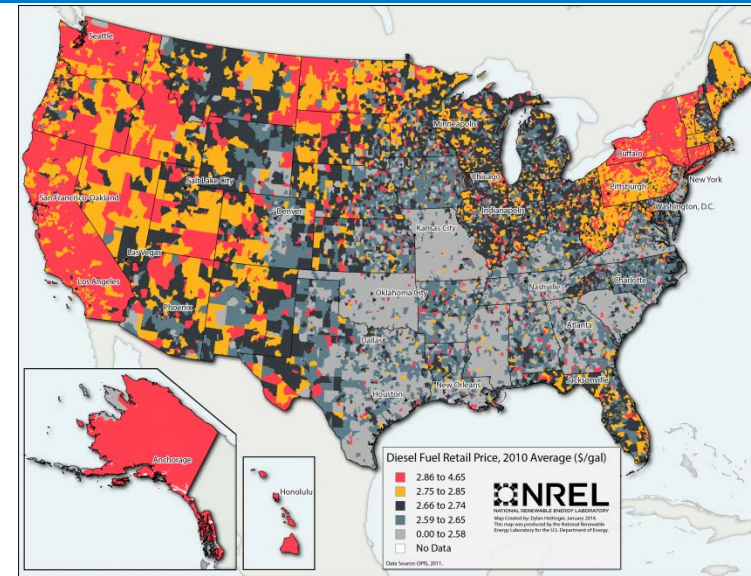
15%
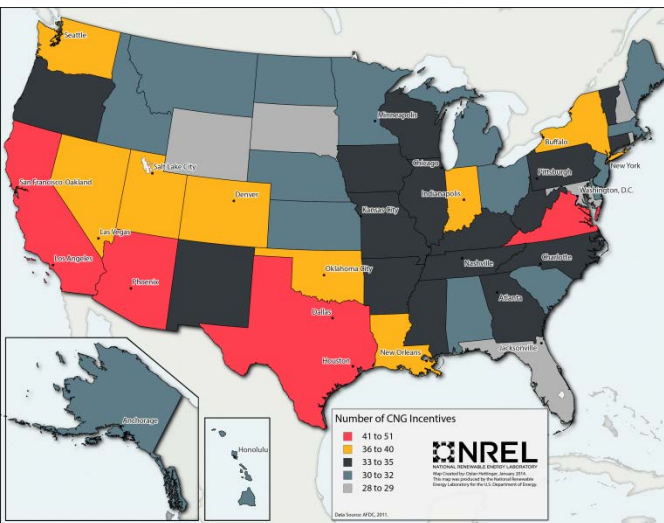
12%
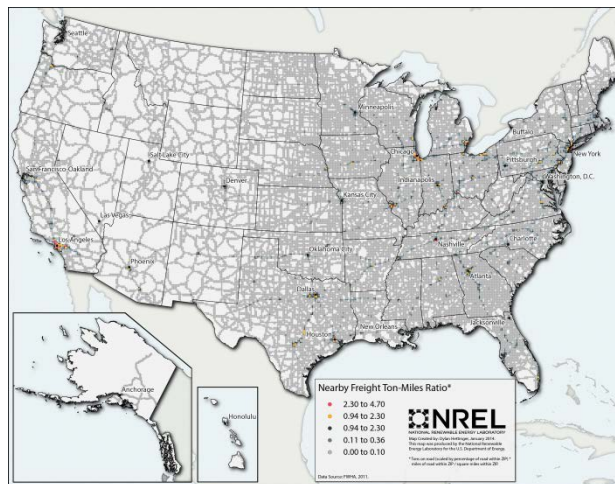
11%
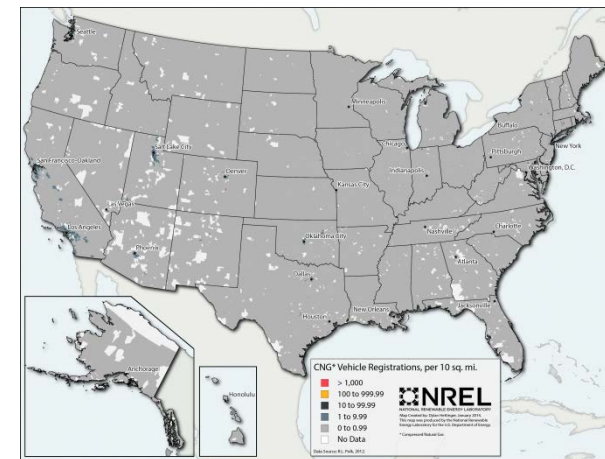
8% **Resource Proximity [Restricted]**

Compressed Natural Gas Markets

Compressed Natural Gas Analysis Score
- 0.99 to 0.34
- 0.35 to 0.28
- 0.29 to 0.28
- 0.27 to 0.22
- 0.23 to 0.02
- Insufficient Data

Map Created by: Dylan Hettinger, August 2013.
This map was produced by the National Renewable
Energy Laboratory for the U.S. Department of Energy.
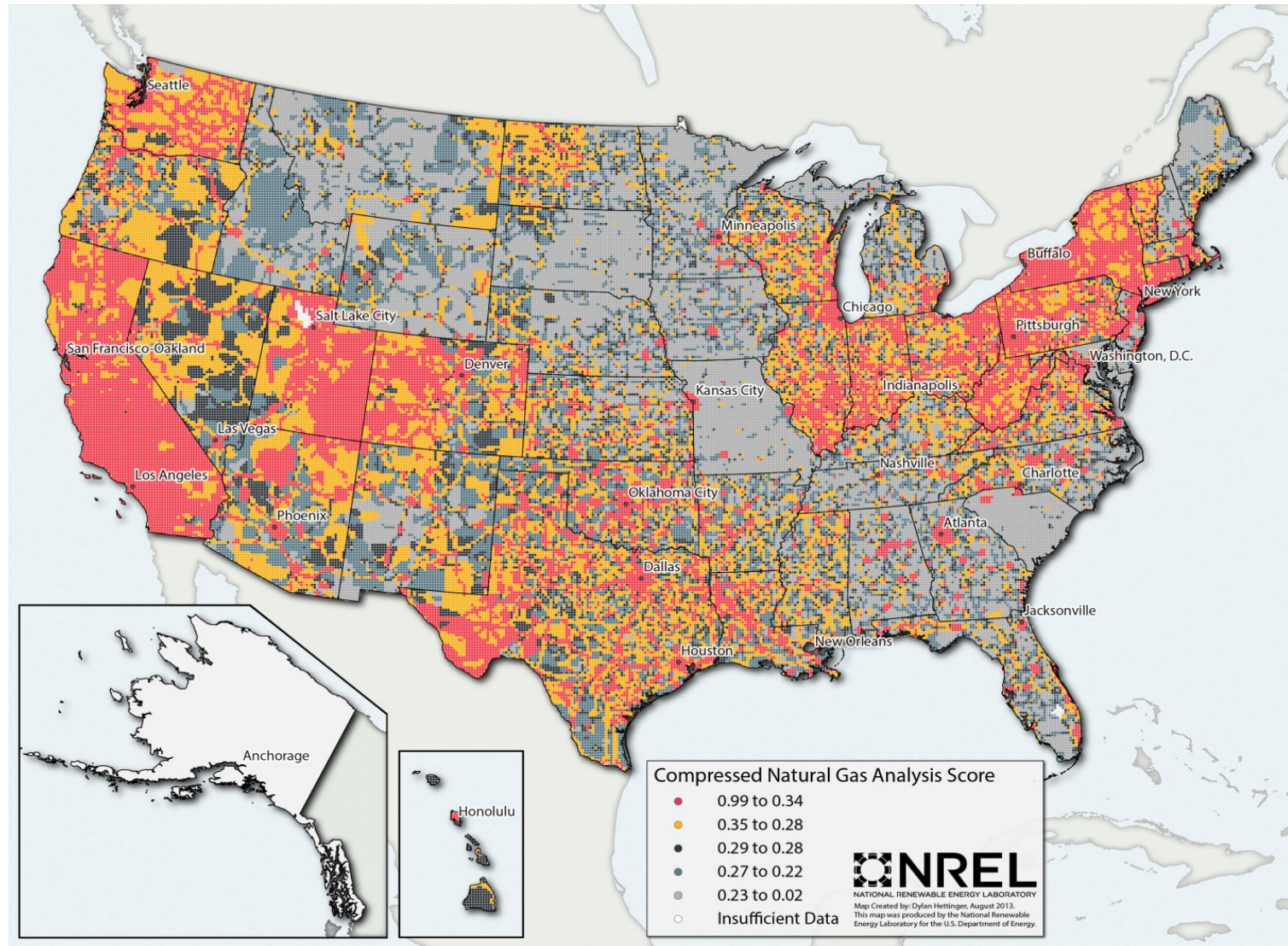
Map of the most active CNG markets

Propane Components

32%
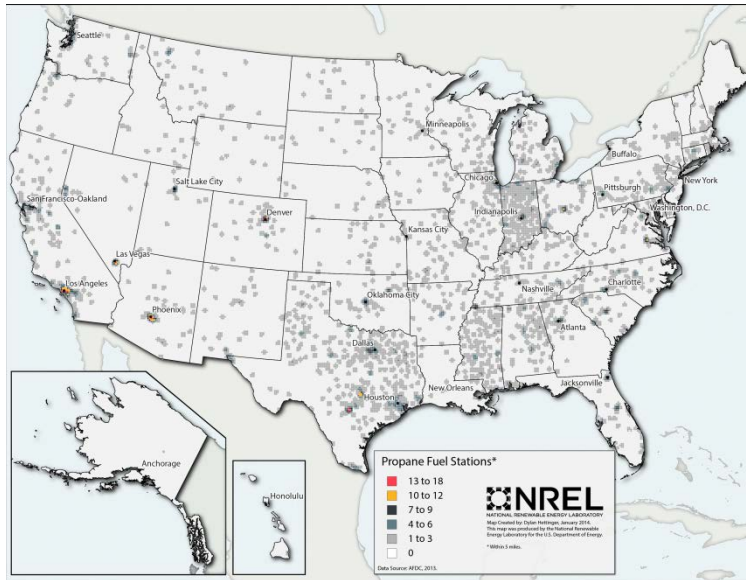
19%
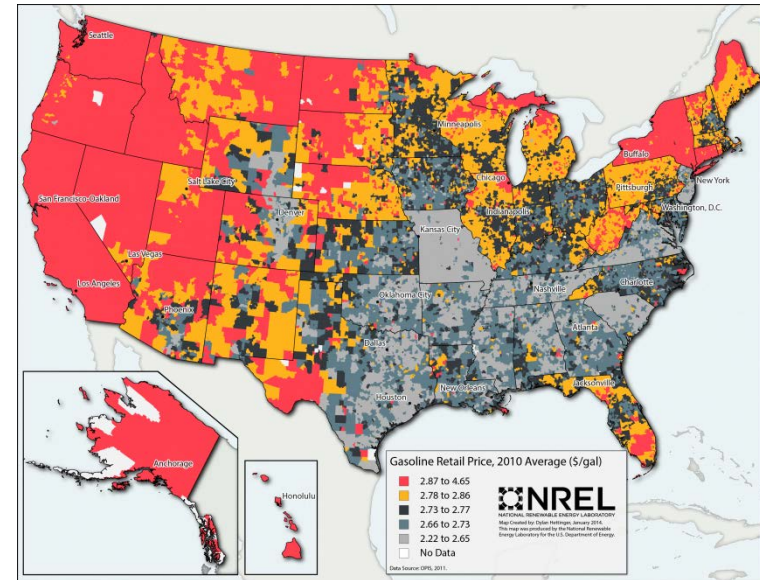
17%
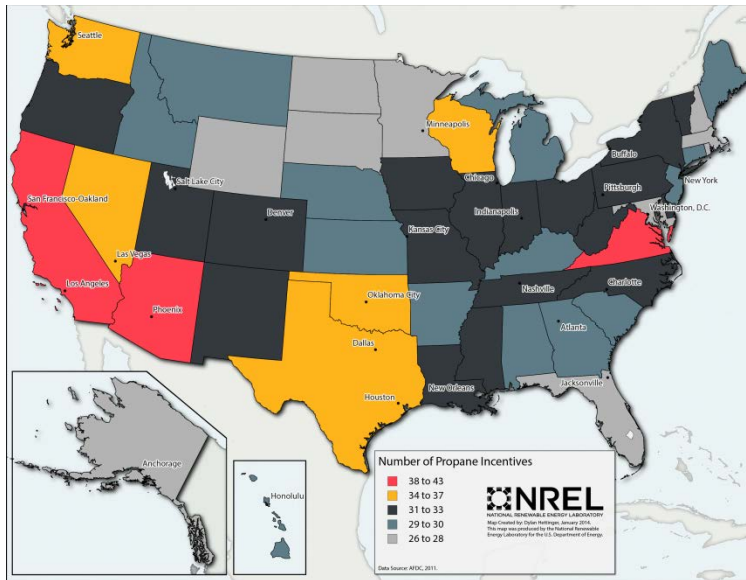
16%
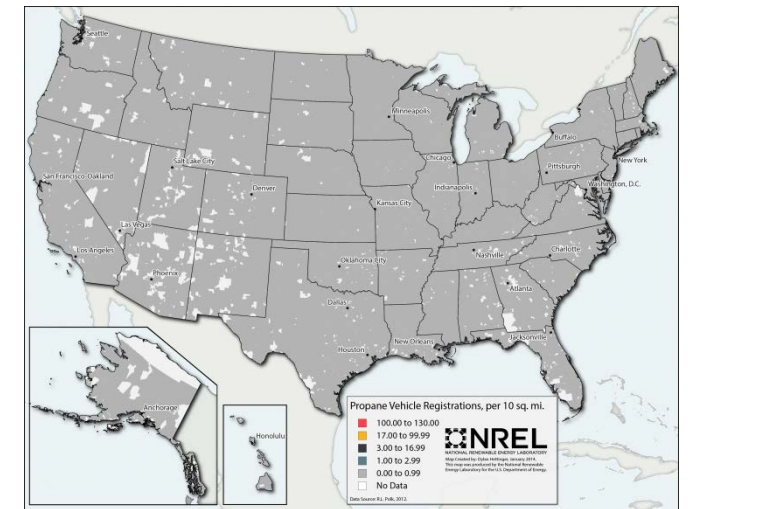
16% **Resource Proximity [Restricted]**

Propane Markets
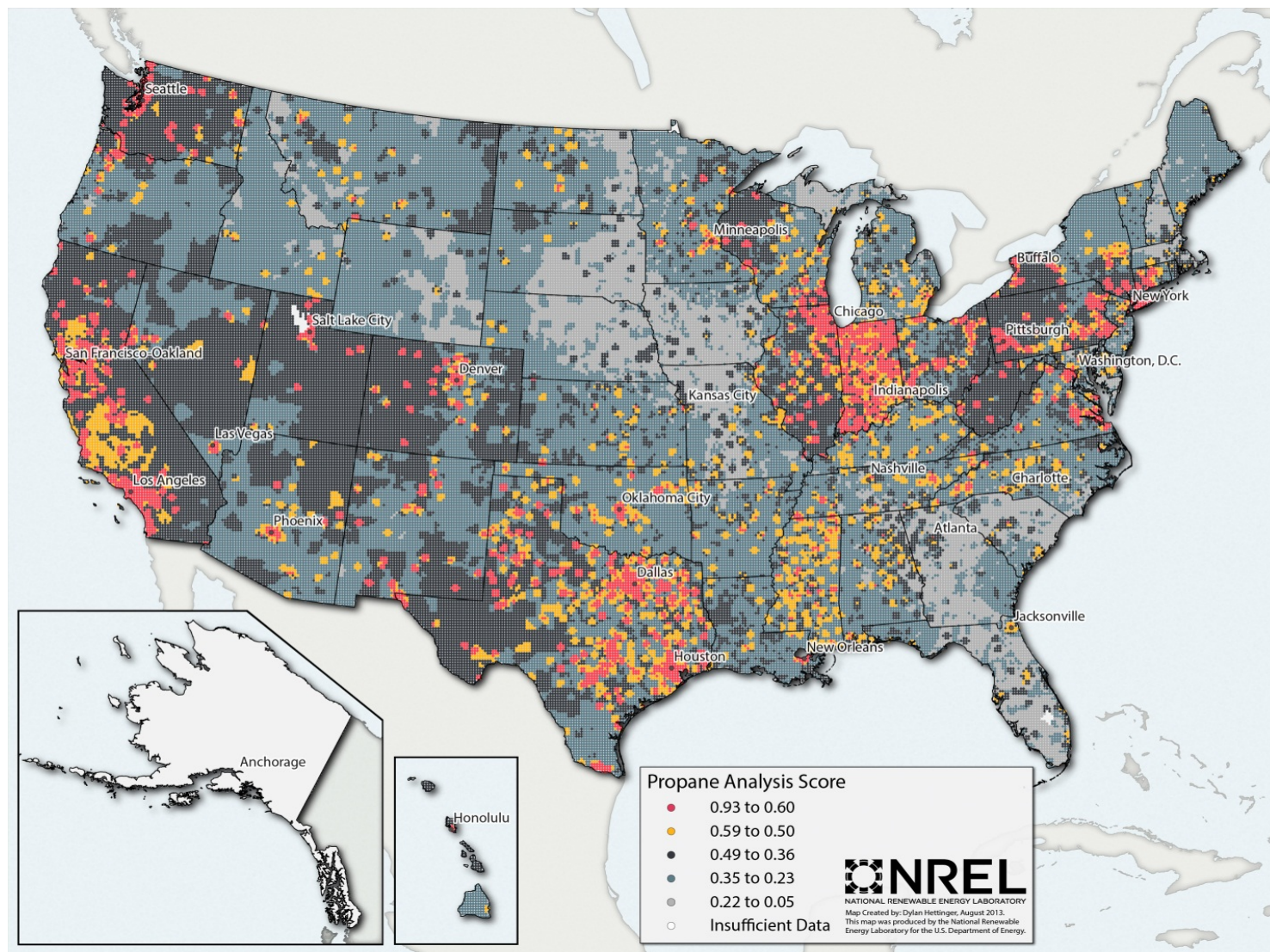
Map of the most active Propane markets

Electricity Components

20%

HEV Density (from TransAtlas)

- > 139 vehicles/5 sq miles
- 91 - 139 vehicles/5 sq miles
- 45.5 - 91 vehicles/5 sq miles
- 5 - 45.5 vehicles/5 sq miles

19%

Electric Charging Stations*
- 82 to 152
- 42 to 81
- 18 to 41
- 6 to 17
- 1 to 5
- 0

16%

Electric Vehicle Registrations, per 10 sq. mi.
- > 100,000
- 85,000 to 99,999
- 1,000 to 84,999
- 100 to 999
- 0 to 99

14%

Gasoline Retail Price, 2010 Average ($/gal)
- 2.87 to 4.65
- 2.78 to 2.86
- 2.73 to 2.77
- 2.66 to 2.73
- 2.22 to 2.65
- No Data

Electricity Components, *continued*

12%

Greenhouse Gas Emissions (CO₂e)*

10%

Number of Electric Vehicle Incentives

9%

Residential PV Installs*
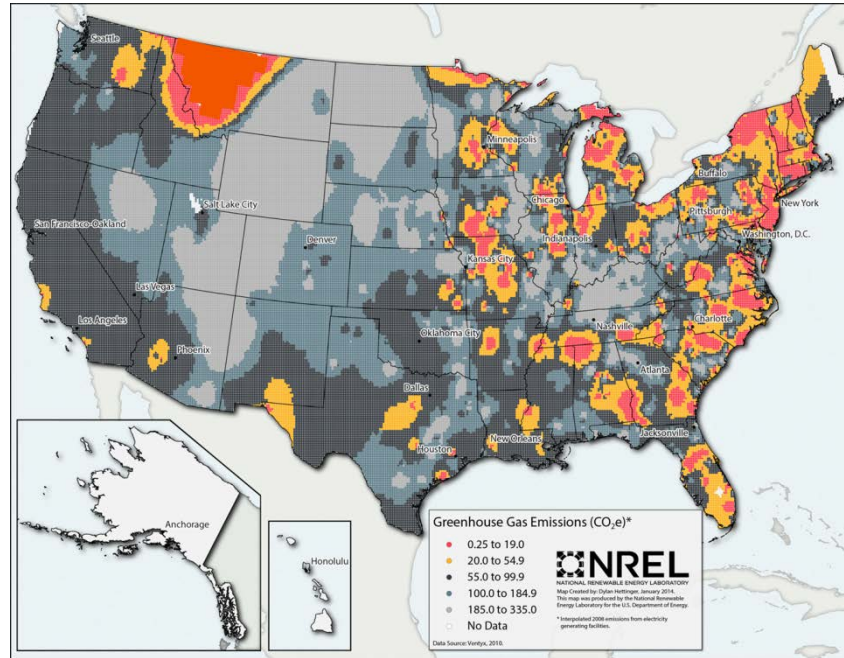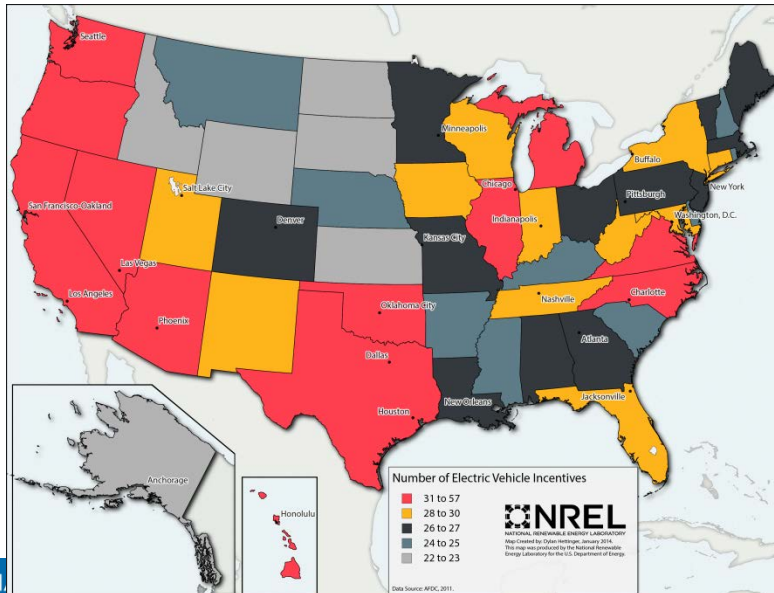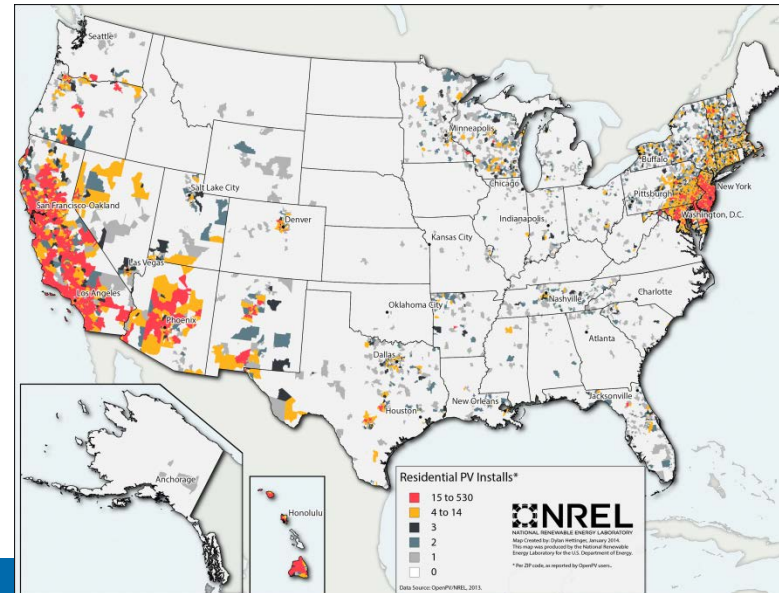
Electricity Markets
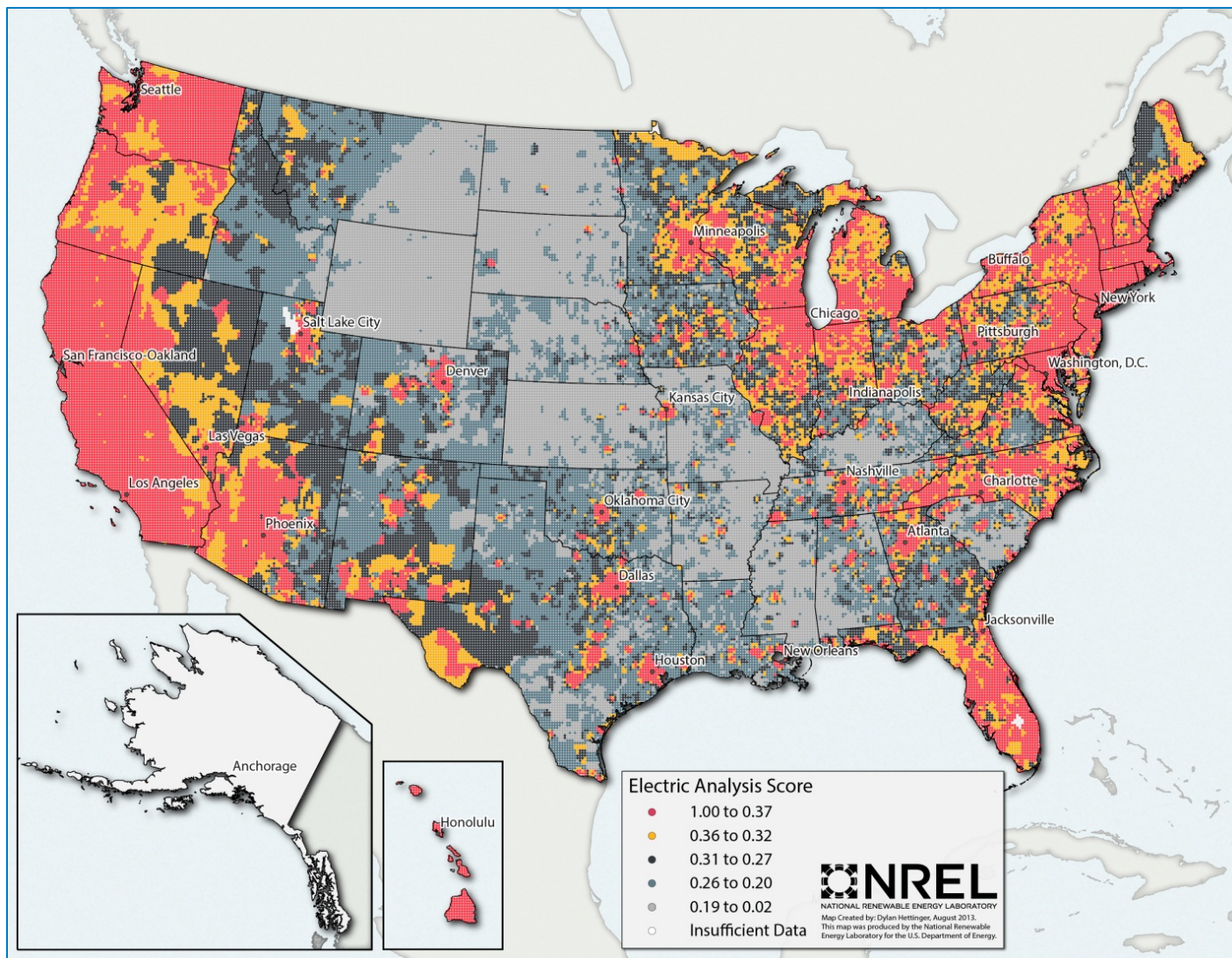
Map of the most active vehicle electricity markets

State-based Summaries

- **Strongest Market Potential**
  - Squares (10kmX10km) in the state receive high scores, as shown by the mean and median scores
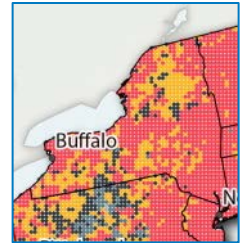
- **Healthy Market Potential**
  - Not quite as good as the strongest, but still uniform (mean and median are close)
  - Surpasses a certain percentage of area in top 2 quintiles (depending on fuel)
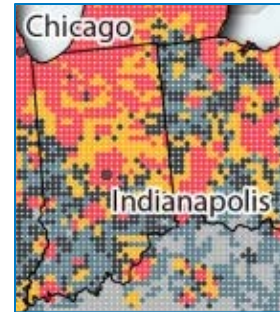
- **Patchy Market Potential**
  - Isolated patches and corridors of strong market potential
  - Different from healthy markets because the squares are not uniform (so median is much lower than mean)
  - Strong market conglomerations must surpass a minimum size
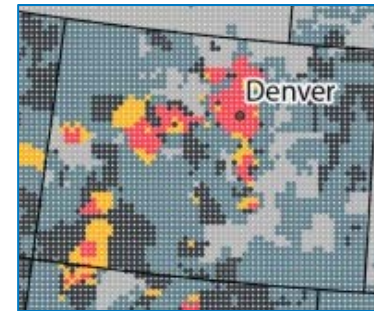
- **Weak Market Potential**
  - Different from patchy because areas of good market are either nonexistent or don't exist in large enough clumps
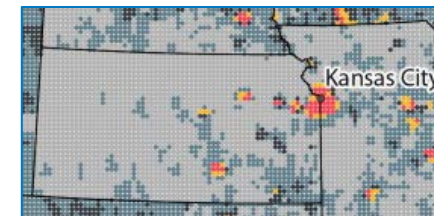
State-based Summaries

Best States for Alt Fuels in General

State	Electric	Biodiesel	Ethanol	CNG	Propane
California	Strong	Strong	Healthy	Strong	Strong
Illinois	Healthy	Strong	Strong	Strong	Strong
Indiana	Healthy	Strong	Strong	Strong	Strong
Pennsylvania	Strong	Strong	Healthy	Strong	Strong
Washington	Strong	Strong	Healthy	Strong	Strong
Ohio	Healthy	Strong	Strong	Strong	Healthy
Connecticut	Strong	Strong	Weak	Strong	Strong
New York	Strong	Healthy	Strong	Strong	Patchy
Rhode Island	Strong	Strong	Weak	Strong	Healthy

States Most Challenging for Alt Fuels in General

State	Electric	Biodiesel	Ethanol	CNG	Propane
Maine	Healthy	Weak	Weak	Weak	Weak
Alabama	Patchy	Patchy	Weak	Patchy	Patchy
New Mexico	Patchy	Patchy	Weak	Patchy	Patchy
Idaho	Weak	Weak	Weak	Patchy	Weak
Wyoming	Weak	Weak	Weak	Patchy	Weak

Clean Cities Overlap

Clean Cities covers 53% of continental U.S. area

Percent of top quintile in CC	
Ethanol	76%
Biodiesel	70%
Propane	67%
CNG	65%
Electric	61%

Conclusions

- **Indicators of good market are existing fueling stations, high vehicle density, high gas prices, good state incentives, and nearby resource**
    - Generally in that order
- **No state has a Weak rating for all five alternative fuels**
- **CNG has high potential in the greatest number of states**
    - Most challenging states have patchy CNG markets
- **California, Illinois, Indiana, Pennsylvania, and Washington appear to be the best states for alternative fuels in general**
- **Clean Cities has a disproportionate area of strong alt fuel markets in its territory**

Questions?

- **Questions?**
- **Feedback?**
- **Expansion Ideas?**
- **Map requests**

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Geography of Existing and Potential Alternative Fuel Markets in the United States

Caley Johnson and Dylan Hettinger

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

This report is available at no cost from the National Renewable Energy
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Technical Report
NREL/TP-5400-60891
November 2014

Contract No. DE-AC36-08GO28308

Google: Geography Existing Alternative Fuels

Supplemental Slides

Market Categorization by State and Fuel

Table 3. Market Categorization by State and Fuel

State	Electricity	Biodiesel	Ethanol	CNG	Propane
Alabama	Patchy	Patchy	Weak	Patchy	Patchy
Alaska	NA	NA	NA	NA	NA
Arizona	Healthy	Patchy	Weak	Healthy	Patchy
Arkansas	Weak	Patchy	Weak	Healthy	Patchy
California	Strongest	Strongest	Healthy	Strongest	Strongest
Colorado	Patchy	Patchy	Patchy	Strongest	Healthy
Connecticut	Strongest	Strongest	Weak	Strongest	Strongest
Delaware	Strongest	Healthy	Weak	Weak	Healthy
Florida	Strongest	Healthy	Healthy	Patchy	Weak
Georgia	Patchy	Healthy	Patchy	Patchy	Weak
Hawaii	Strongest	Healthy	Weak	Healthy	Patchy
Idaho	Weak	Weak	Weak	Patchy	Weak
Illinois	Healthy	Strongest	Strongest	Strongest	Strongest
Indiana	Healthy	Strongest	Strongest	Strongest	Strongest
Iowa	Patchy	Strongest	Strongest	Weak	Weak
Kansas	Weak	Patchy	Strongest	Healthy	Patchy
Kentucky	Weak	Healthy	Healthy	Patchy	Patchy
Louisiana	Patchy	Patchy	Weak	Healthy	Patchy
Maine	Healthy	Weak	Weak	Weak	Weak
Maryland	Strongest	Healthy	Patchy	Weak	Patchy
Massachusetts	Strongest	Strongest	Patchy	Strongest	Patchy
Michigan	Strongest	Patchy	Healthy	Patchy	Patchy
Minnesota	Patchy	Patchy	Strongest	Weak	Patchy
Mississippi	Weak	Patchy	Weak	Healthy	Healthy
Missouri	Weak	Patchy	Healthy	Weak	Weak
Montana	Patchy	Weak	Weak	Weak	Patchy
Nebraska	Weak	Weak	Strongest	Patchy	Weak
Nevada	Healthy	Weak	Weak	Healthy	Patchy

Market Categorization by State and Fuel

Table 3. Market Categorization by State and Fuel

State	Electricity	Biodiesel	Ethanol	CNG	Propane
New Hampshire	Strongest	Patchy	Weak	Weak	Weak
New Jersey	Strongest	Healthy	Weak	Strongest	Patchy
New Mexico	Patchy	Patchy	Weak	Patchy	Patchy
New York	Strongest	Healthy	Strongest	Strongest	Patchy
North Carolina	Strongest	Strongest	Healthy	Patchy	Patchy
North Dakota	Weak	Healthy	Strongest	Patchy	Weak
Ohio	Healthy	Strongest	Strongest	Strongest	Healthy
Oklahoma	Patchy	Patchy	Patchy	Healthy	Patchy
Oregon	Strongest	Patchy	Patchy	Healthy	Patchy
Pennsylvania	Strongest	Strongest	Healthy	Strongest	Strongest
Rhode Island	Strongest	Strongest	Weak	Strongest	Healthy
South Carolina	Patchy	Healthy	Patchy	Weak	Weak
South Dakota	Weak	Patchy	Strongest	Weak	Weak
Tennessee	Patchy	Strongest	Strongest	Patchy	Patchy
Texas	Patchy	Patchy	Patchy	Healthy	Strongest
Utah	Patchy	Weak	Weak	Strongest	Healthy
Vermont	Strongest	Healthy	Weak	Strongest	Patchy
Virginia	Healthy	Strongest	Patchy	Healthy	Patchy
Washington	Strongest	Strongest	Healthy	Strongest	Strongest
West Virginia	Healthy	Patchy	Weak	Strongest	Strongest
Wisconsin	Healthy	Healthy	Strongest	Healthy	Healthy
Wyoming	Weak	Weak	Weak	Patchy	Weak

Sample Data Behind Market Categorization

Table A-1 State Electric Vehicle Market Categorization Data

State	Category	Mean MV	Median MV	Mean–Median	Area of Top Two Quintiles (square km)	Notes
HI	Strongest	0.627	0.616	0.011	16,700	
CT	Strongest	0.621	0.635	-0.014	12,600	
MA	Strongest	0.537	0.529	0.008	20,600	
CA	Strongest	0.522	0.485	0.037	407,900	
NJ	Strongest	0.508	0.518	-0.010	18,600	
RI	Strongest	0.487	0.487	0.000	2,700	
MD	Strongest	0.479	0.464	0.015	23,000	
VT	Strongest	0.458	0.447	0.011	24,600	
WA	Strongest	0.442	0.413	0.029	174,000	
DE	Strongest	0.440	0.404	0.036	4,600	

Notes column explains rationale for break points between categories