# Geographically-Based Hydrogen Demand & Infrastructure Rollout Scenario Analysis

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Project # TVP2

This presentation does not contain any proprietary, confidential, or otherwise restricted information

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Presented at the 2007 DOE Hydrogen Program Annual Merit Review and Peer Evaluation on May 15-18, 2007 in Arlington, Virginia.

# Overview

## Timeline

- Project start: October 2004
- Project end: May 2007
- Percent complete: 100%

## Budget

- Total Funding: $605K
  - FY 2005: $200K
  - FY 2006: $180K
  - FY 2007: $225K

## Barriers

- Tech Validation C
  - Hydrogen refueling infrastructure
- Systems Analysis A
  - Future market behavior

## Collaborators

- DTI, ORNL

# Objectives

## FY 2007

- Identify best infrastructure scenarios to meet key transition scenarios
- Identify implementation issues

## FY 2006

- Quantify hydrogen demand in the U.S.
- Estimate costs to support infrastructure to meet emerging hydrogen demand

## FY 2005

- Quantify and locate a minimal interstate-based hydrogen infrastructure

# Approach

- Using results from FY 2005 and FY 2006 demand analyses
  - Use GIS techniques to site infrastructure
  - Evaluate benefits and challenges to various scenarios
  - Develop a roll-out strategy for infrastructure

# Objective/Overview

Lay out several scenarios for infrastructure deployment in the 2012-2025 timeframe

2012-2015: Initial introduction

2016-2019: Targeted regional growth

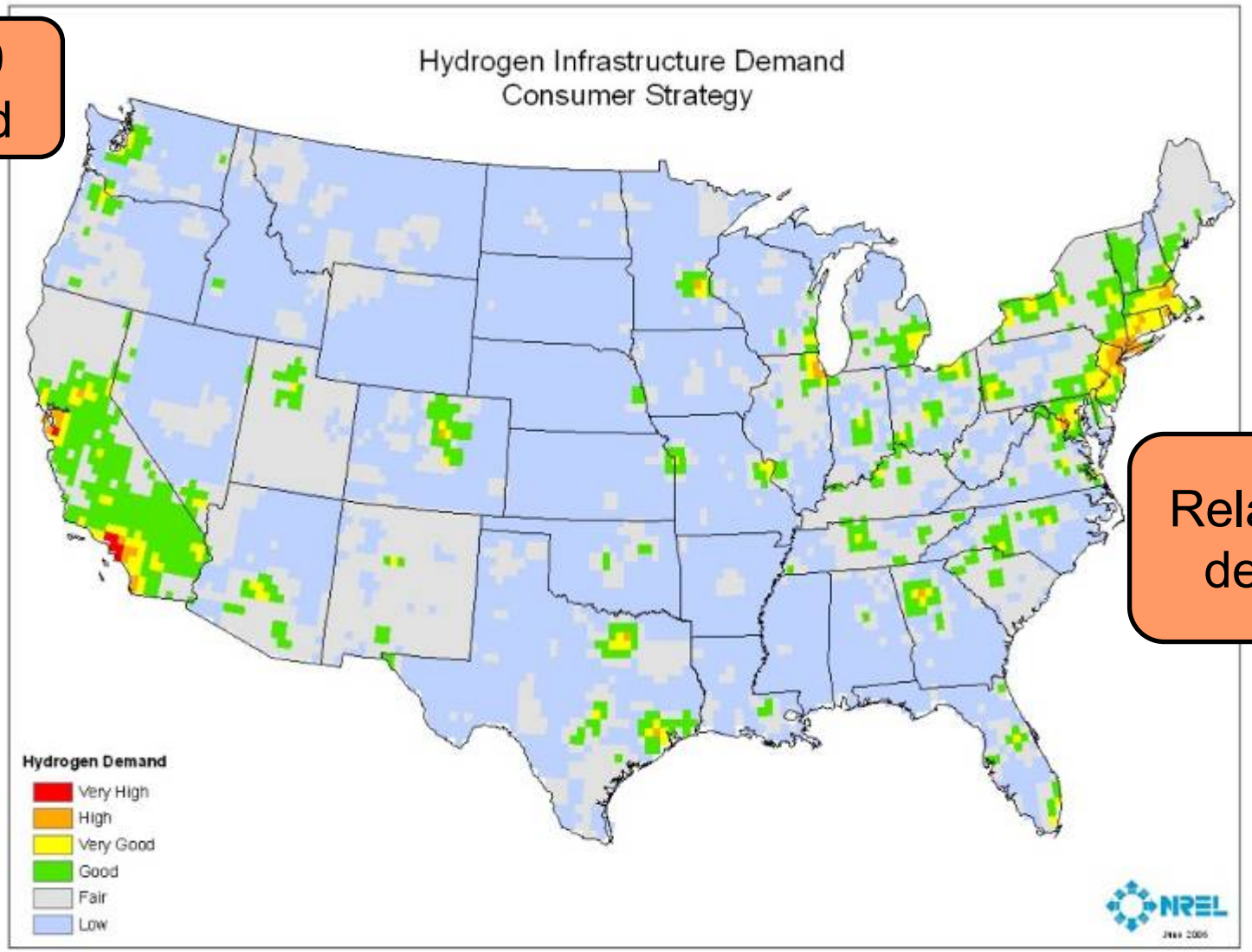
2020-2025: Inter-regional expansion

# Approach

- Identify infrastructure to support deployment scenarios in the 2015-2025 timeframe
  - Based on HyTrans estimates for station needs in a given time period
    - Scenario 2: 5M vehicles, 4,000 refueling stations in 2025
    - Scenario 3: 10M vehicles, 8,000 refueling stations in 2025
  - Emphasis on urban deployment to best match anticipated hydrogen demand

# Baseline $H_2$ Demand Results

20 X 20 mile grid




Relative $H_2$ demand

# Applied Lessons Learned

Lessons learned feedback gathered in Golden, CO, in July 2006

## Participants

- Vehicle manufacturers
- Fuel providers
- Policy makers
- Fleet operators
- Clean Cities coordinators
- Research & development participants
- Trade associations
- DOE participants

## Relevant Outcomes to Scenario Analysis

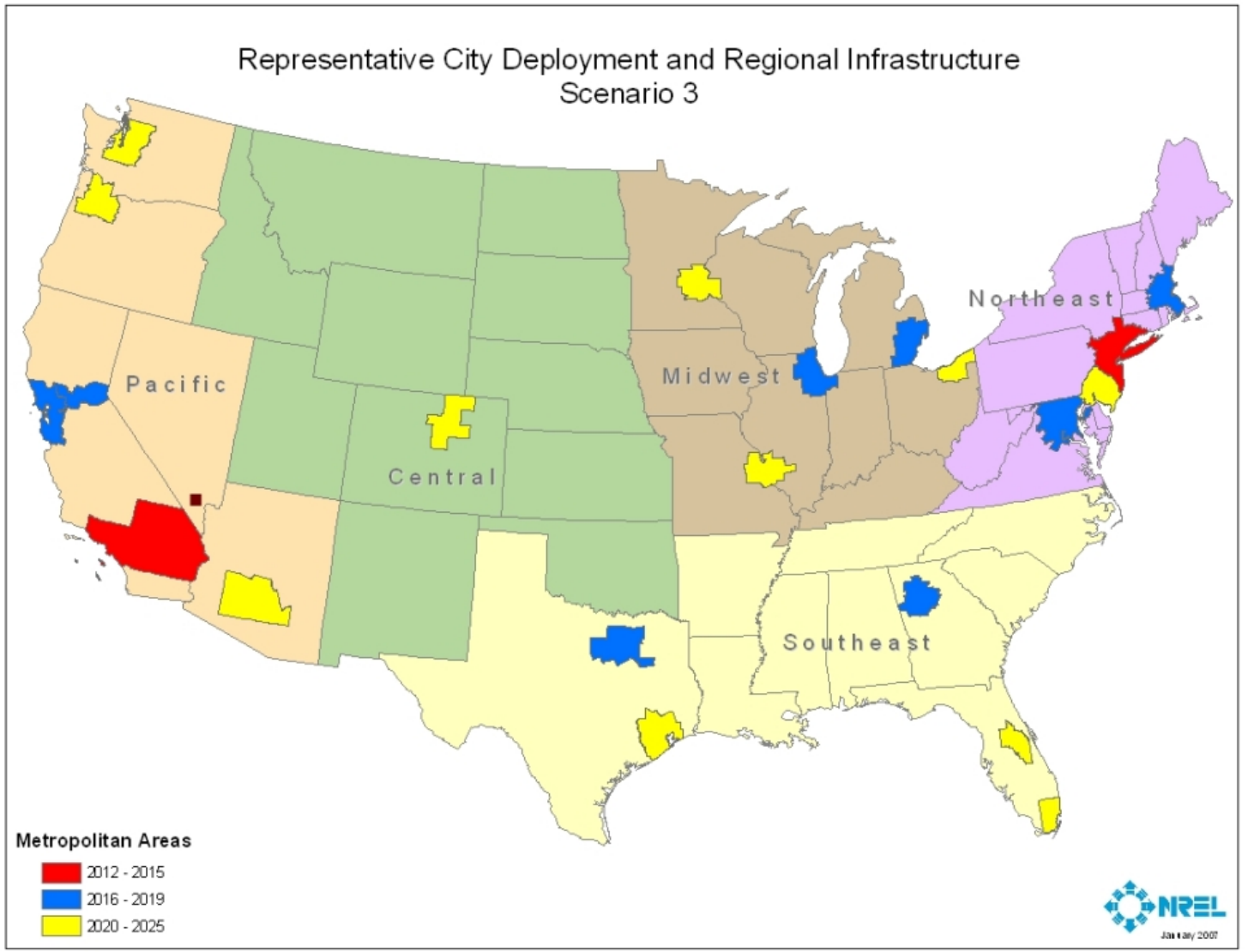
- Fleets sustain fuel market; consumers sustain vehicle markets
- Coordination is vital
  - Infrastructure and vehicle deployment
- Incentives and mandates are both important
  - Right ones
  - Right time
- Backing from agencies necessary
  - Fire, safety, permitting, insurance
- Local level efforts are necessary
  - Public education
  - Codes and standards/safety

# Top Urban Areas
# Lighthouse Concept Targets

- Los Angeles/Riverside/Orange County/San Diego
- New York/Northern NJ/Long Island
- San Francisco/Oakland/San Jose/Sacramento/Yolo
- Boston/Worcester/Lawrence
- Washington/Baltimore
- Chicago/Gary/Kenosha
- Detroit/Ann Arbor/Flint
- Dallas/Fort Worth
- Atlanta
- Houston/Galveston/Brazoria
- St. Louis
- Minneapolis/St. Paul
- Philadelphia/Wilmington/ Atlantic City
- Phoenix/Mesa
- Denver/Boulder/Greeley

Urban areas = F ($H_2$ demand, population, vehicles)

# Regional Deployment Approach



# Deployment Scenarios
# Infrastructure Rollout

| | 2012-2015 | 2016-2020 | 2021-2025 |
|---|---|---|---|
| **Scenario 1**<br>Limited Cities | <100 Stations | ~200 Stations | ~1,500 Stations |
| **Scenario 2**<br>All 20 Cities | <100 Stations | ~1,200 Stations | ~4,000 Stations |
| **Scenario 3**<br>All 20 Cities | <100 Stations | ~1,400 Stations | ~8,000 Stations |

7%

15%

4,000 stations represents ~7% of existing stations in selected cities

8,000 stations represents ~15% of existing stations in selected cities

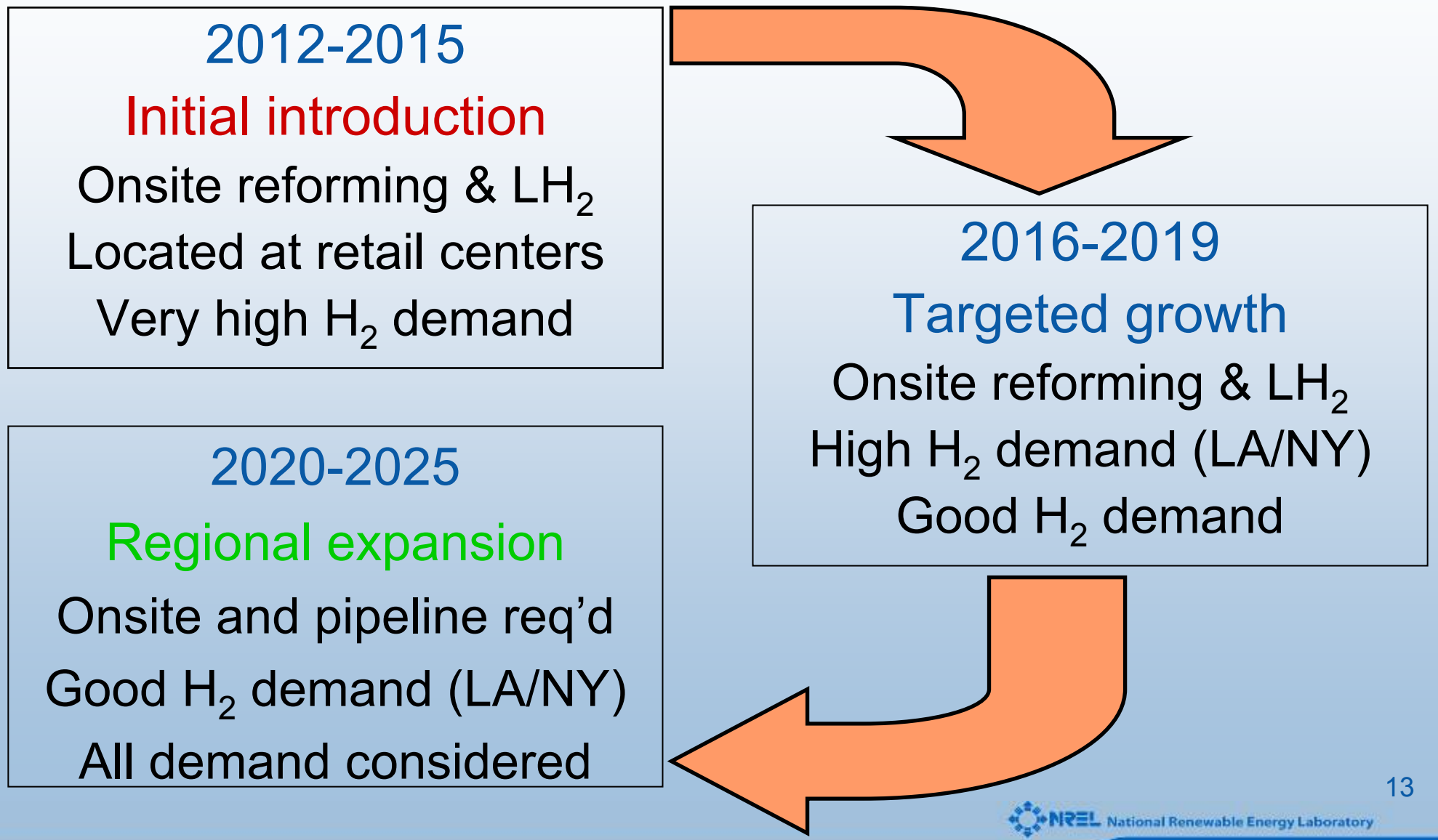
# Infrastructure Rollout

| Urban Area | 2012-2015 Stations | 2016-2019 Stations | Scenario 2<br>2020-2025 Stations | Scenario 3<br>2021-2025 Stations |
|---|---|---|---|---|
| NY | 20 | 200 | 554 | 1227 |
| LA | 40 | 400 | 751 | 965 |
| San Fran/Sacramento | | 78 | 181 | 401 |
| Boston | | 127 | 296 | 656 |
| Detroit | | 90 | 210 | 465 |
| Chicago | | 135 | 316 | 699 |
| Dallas | | 92 | 215 | 477 |
| Atlanta | | 74 | 173 | 382 |
| Philadelphia | | 58 | 136 | 302 |
| Seattle | | 27 | 63 | 140 |
| Portland | | | 55 | 123 |
| Houston | | | 192 | 425 |
| Denver | | | 88 | 196 |
| Minneapolis | | | 98 | 217 |
| Washington | | | 265 | 586 |
| Miami | | | 50 | 111 |
| Orlando | | | 35 | 77 |
| St. Louis | | | 85 | 188 |
| Phoenix | | | 99 | 219 |
| Cleveland | | | 83 | 183 |
| **Total** | **60** | **1282** | **3895** | **7939** |

7%

15%

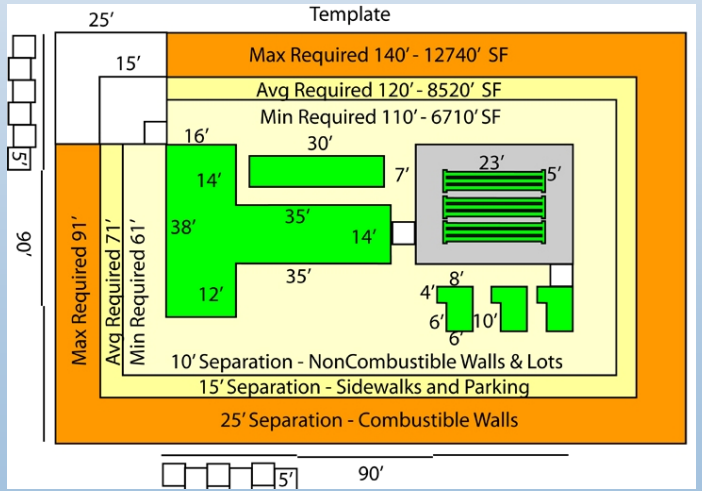
# Infrastructure Strategy



# Infrastructure Feasibility Survey

- Examined initial targeted gas stations in LA, NY, Dallas
  - Best demand areas
  - Major civic airports
  - Traffic above 200,000 veh per day
  - Retail center
  - 3,000+ registered vehicles
  - Major and secondary roads
  - Balanced coverage
- Identified land area at station compared to required reforming or delivered liquid $H_2$ space

| City | Feasible | Not Feasible | Borderline |
|---|---|---|---|
| LA | 5 | 20 | 15 |
| NY | 4 | 15 | 21 |
| Dallas | 7 | 14 | 19 |




Should we consider pipeline sooner?

# Infrastructure Rollout

| Urban Area | 2012-2015 Stations | 2016-2019 Stations | Scenario 2 2020-2025 Stations | Scenario 3 2021-2025 Stations |
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| | | 58 | 136 | 302 |
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| Minneapolis | | | 98 | 217 |
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| Miami | | | 50 | 111 |
| Orlando | | | 35 | 77 |
| St. Louis | | | 85 | 188 |
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| **Total** | **60** | **1282** | **3895** | **7939** |

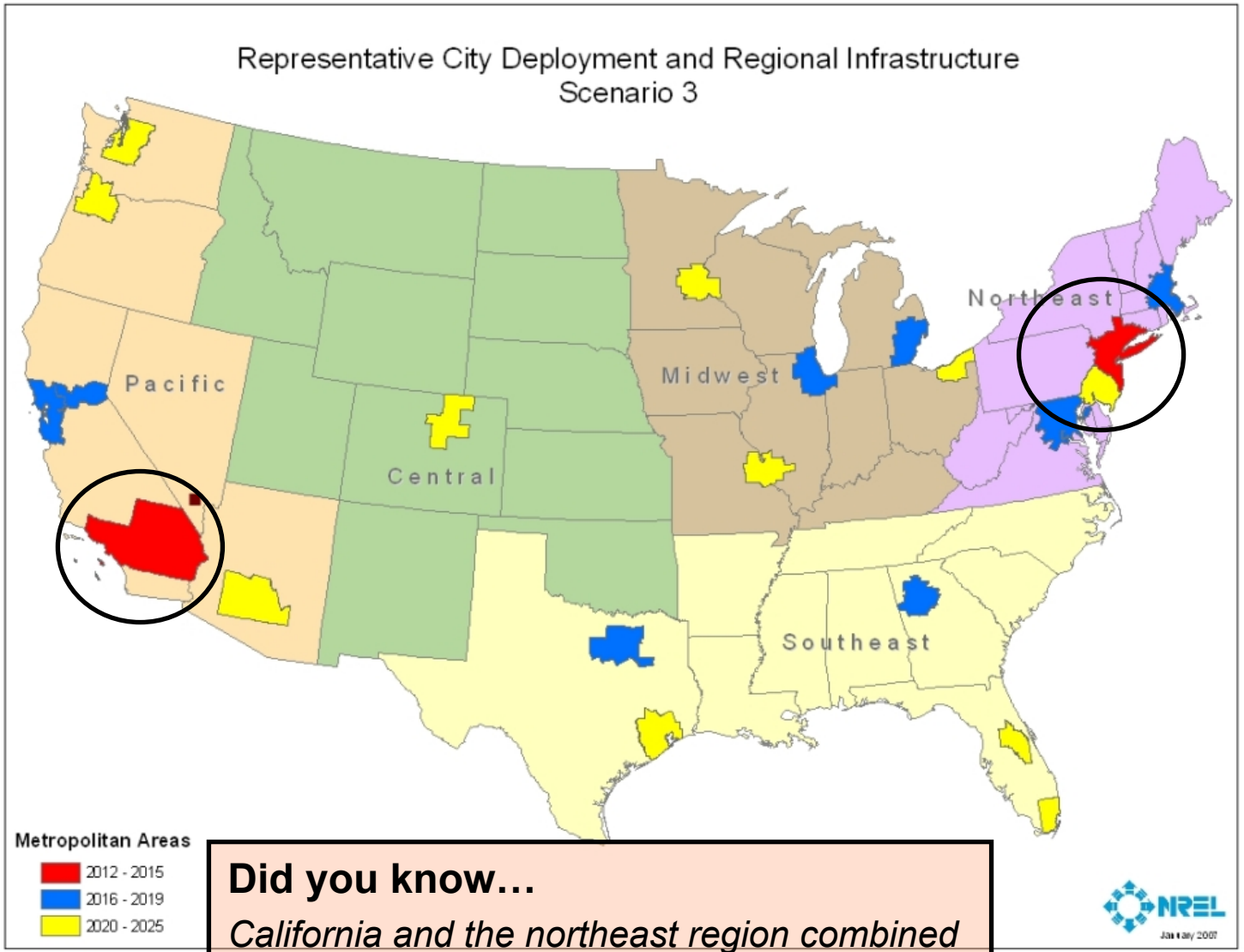
2012-2015: Initial introduction

Onsite reforming & $LH_2$ focus

Located at retail centers

Very high $H_2$ demand

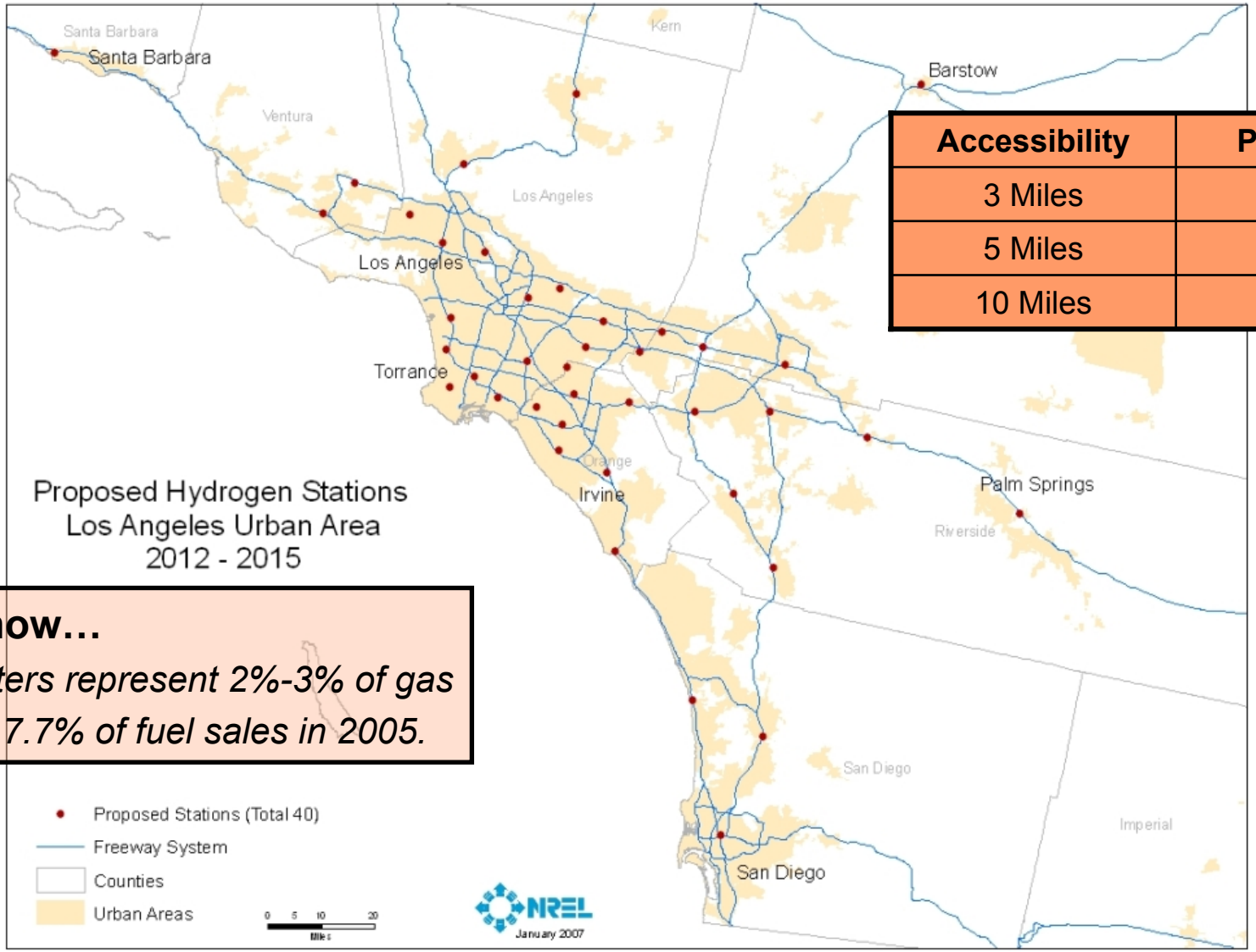
# 2012-2015: Initial Introduction




**Did you know…**

*California and the northeast region combined represent 33% of U.S. gasoline consumption.*

# 2012-2015: Initial Introduction - LA

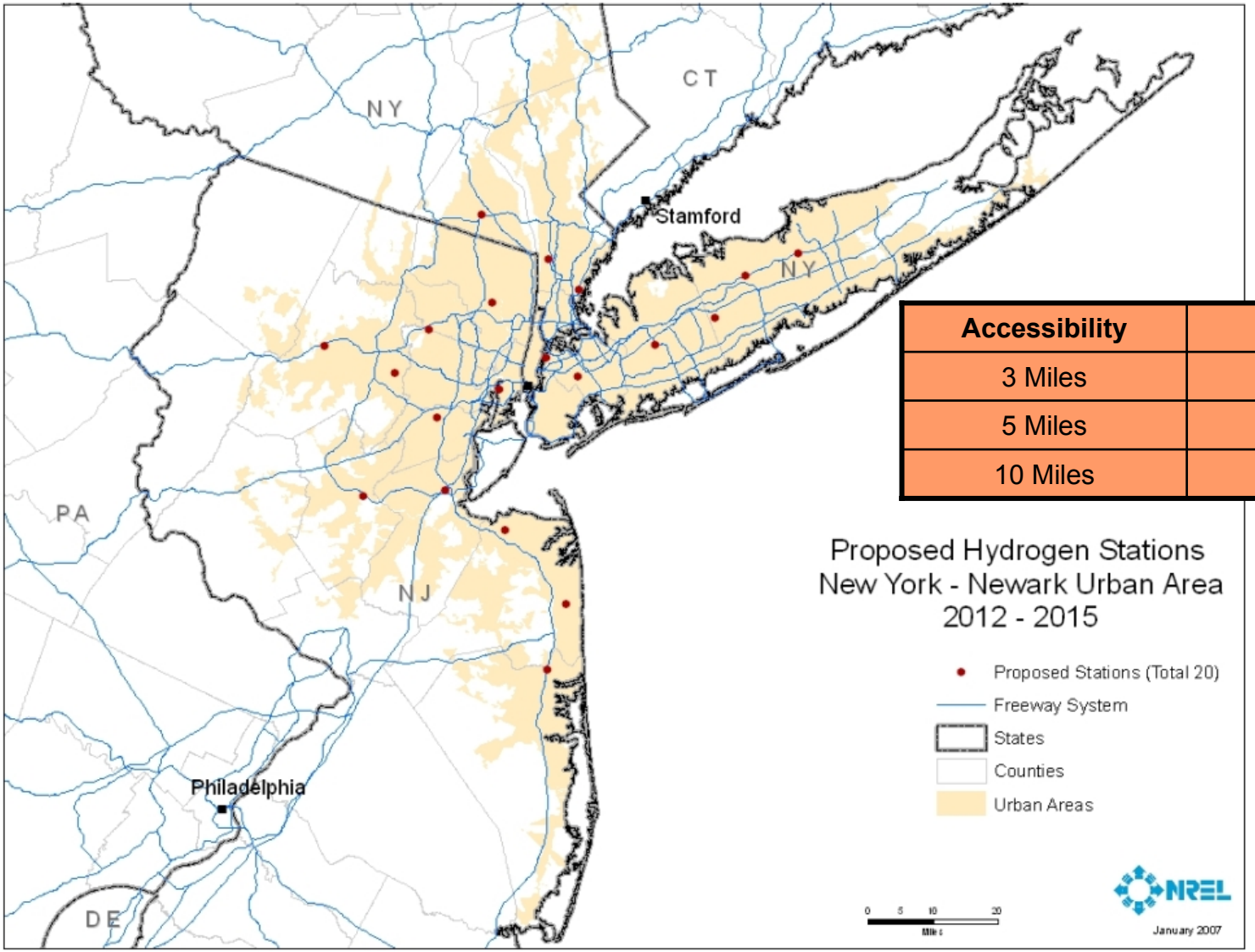



| Accessibility | Population |
|---|---|
| 3 Miles | 23% |
| 5 Miles | 51% |
| 10 Miles | 88% |

**Did you know…**

*Hypermarketers represent 2%-3% of gas stations and 7.7% of fuel sales in 2005.*

# 2012-2015: Initial Introduction - NY




| Accessibility | Population |
|---|---|
| 3 Miles | 12% |
| 5 Miles | 31% |
| 10 Miles | 66% |

# Infrastructure Rollout

| Urban Area | 2012-2015 Stations | 2016-2019 Stations | Scenario 2 2020-2025 Stations | Scenario 3 2021-2025 Stations |
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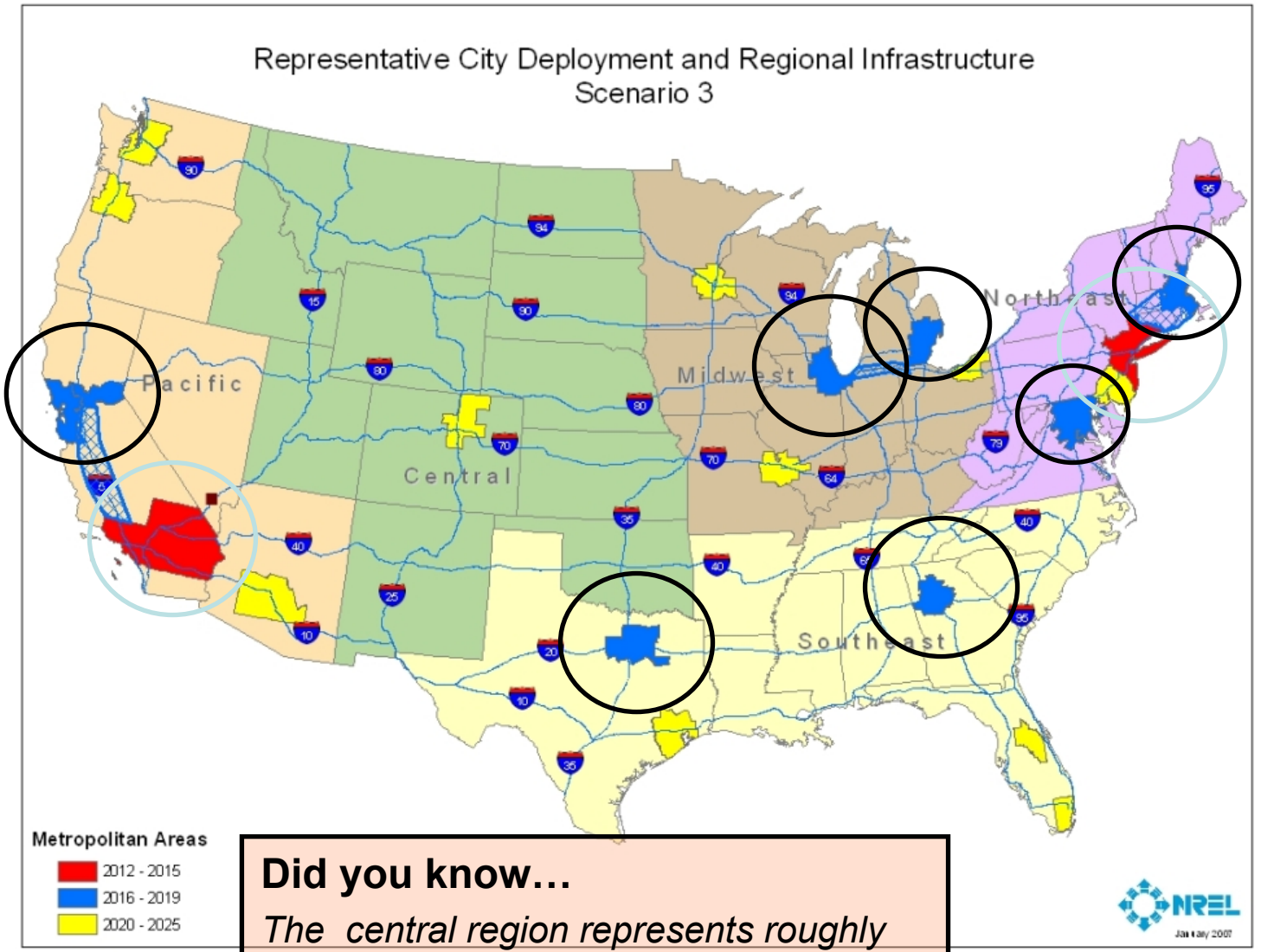
| **Total** | **60** | **1282** | **3895** | **7939** |

2016-2019: Targeted growth
Onsite reforming & $LH_2$ focus
High $H_2$ demand (LA/NY)
Good $H_2$ demand

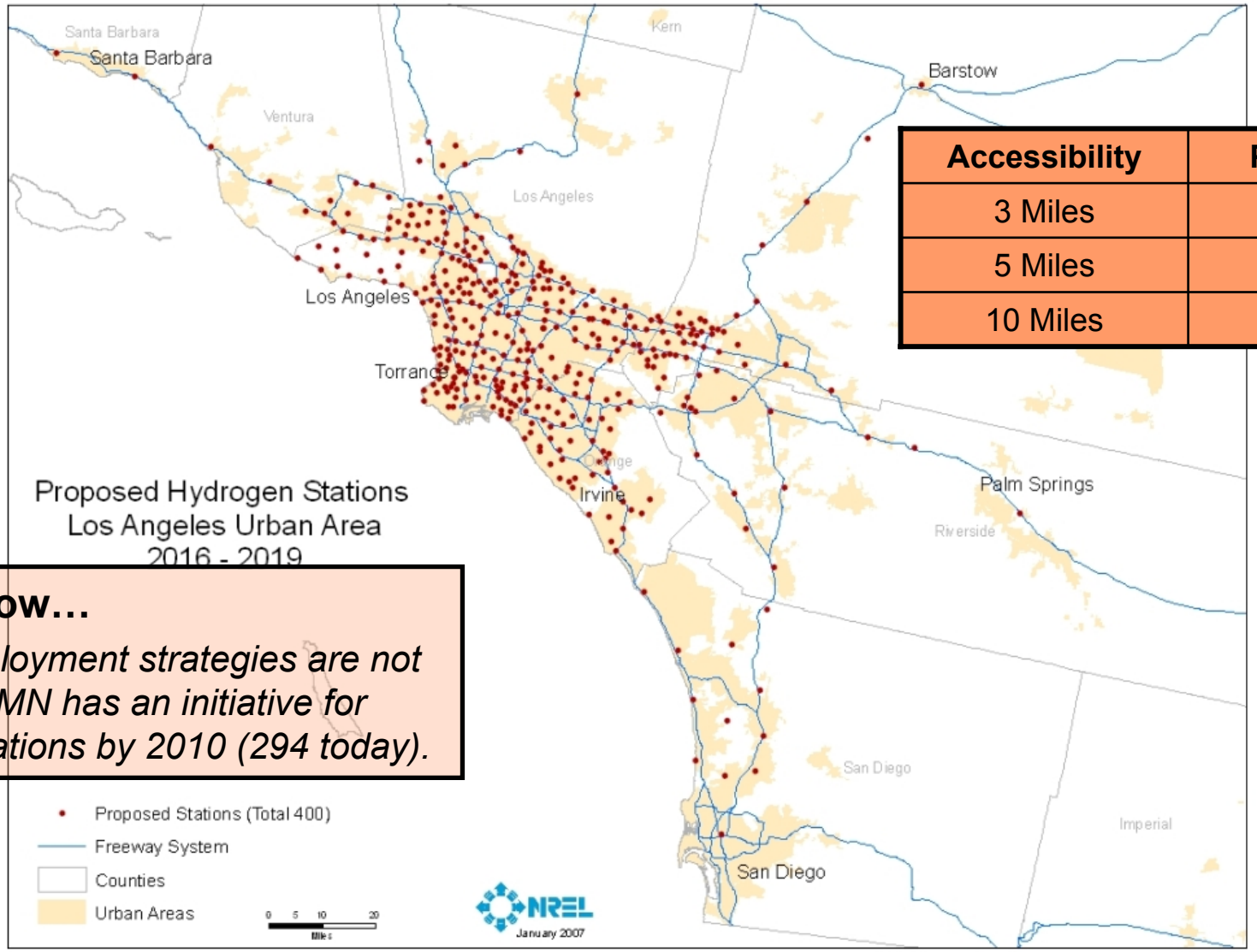
# 2016-2019: Targeted Growth




**Did you know…**

*The central region represents roughly 10% of U.S. gasoline consumption.*

# 2016-2019: Targeted Growth - LA

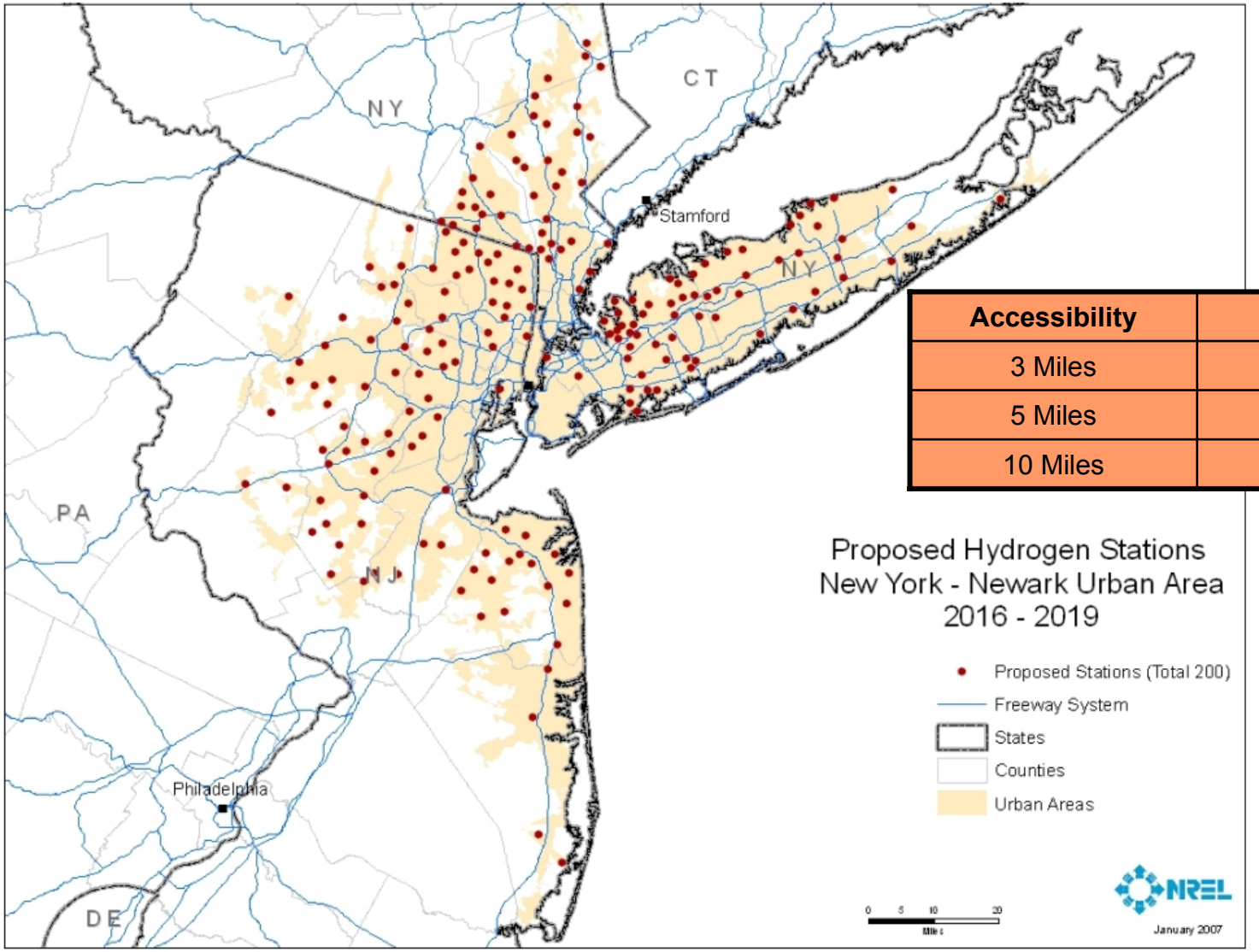



| Accessibility | Population |
|---|---|
| 3 Miles | 73% |
| 5 Miles | 83% |
| 10 Miles | 94% |

**Did you know…**

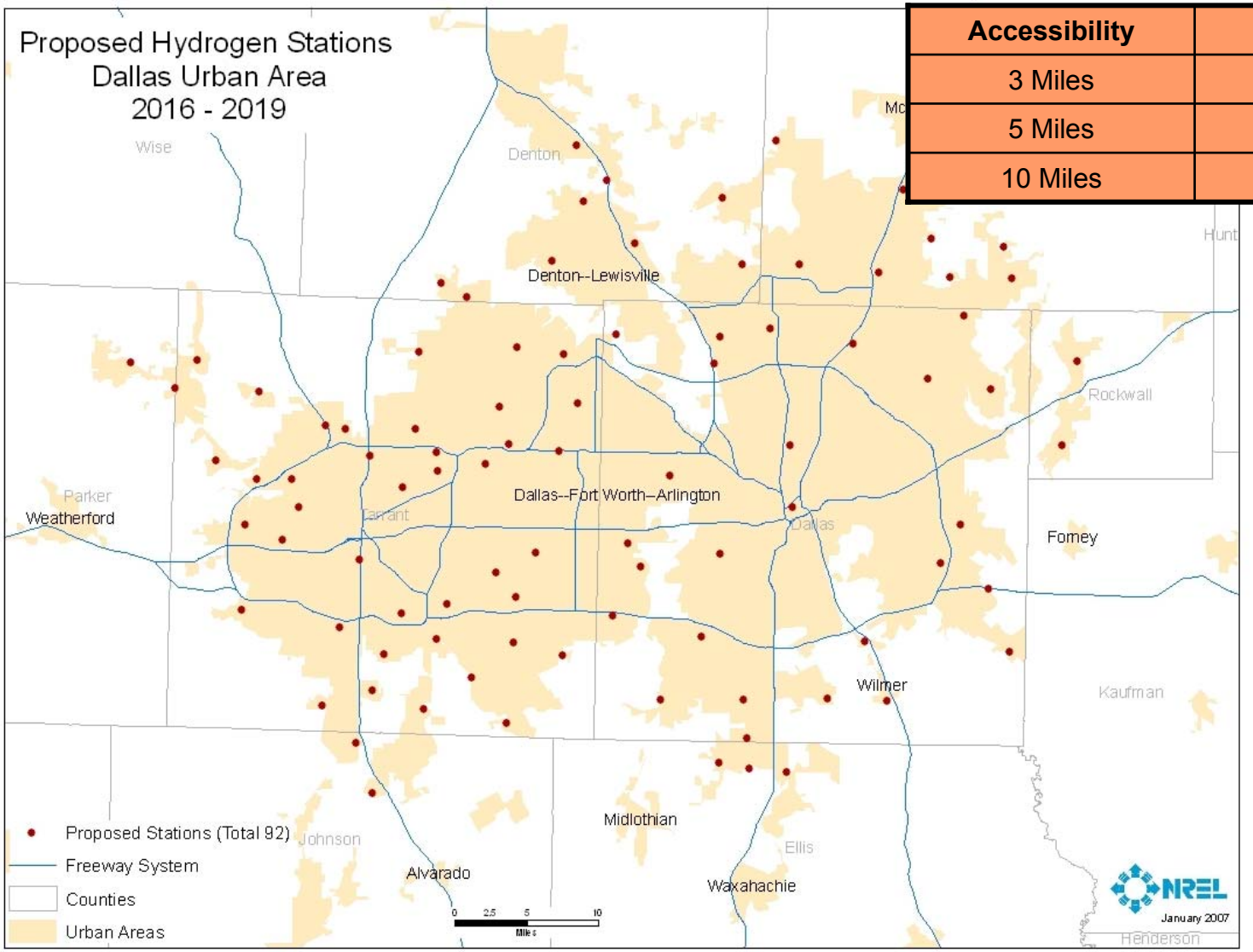
*Targeted deployment strategies are not uncommon. MN has an initiative for 1,800 E85 stations by 2010 (294 today).*

# 2016-2019: Targeted Growth - NY




| Accessibility | Population |
|---|---|
| 3 Miles | 57% |
| 5 Miles | 73% |
| 10 Miles | 76% |

# 2016-2019: Targeted Growth - Dallas




| Accessibility | Population |
|---|---|
| 3 Miles | 62% |
| 5 Miles | 86% |
| 10 Miles | 96% |

# Infrastructure Rollout

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| **Total** | **60** | **1282** | **3895** | **7939** |

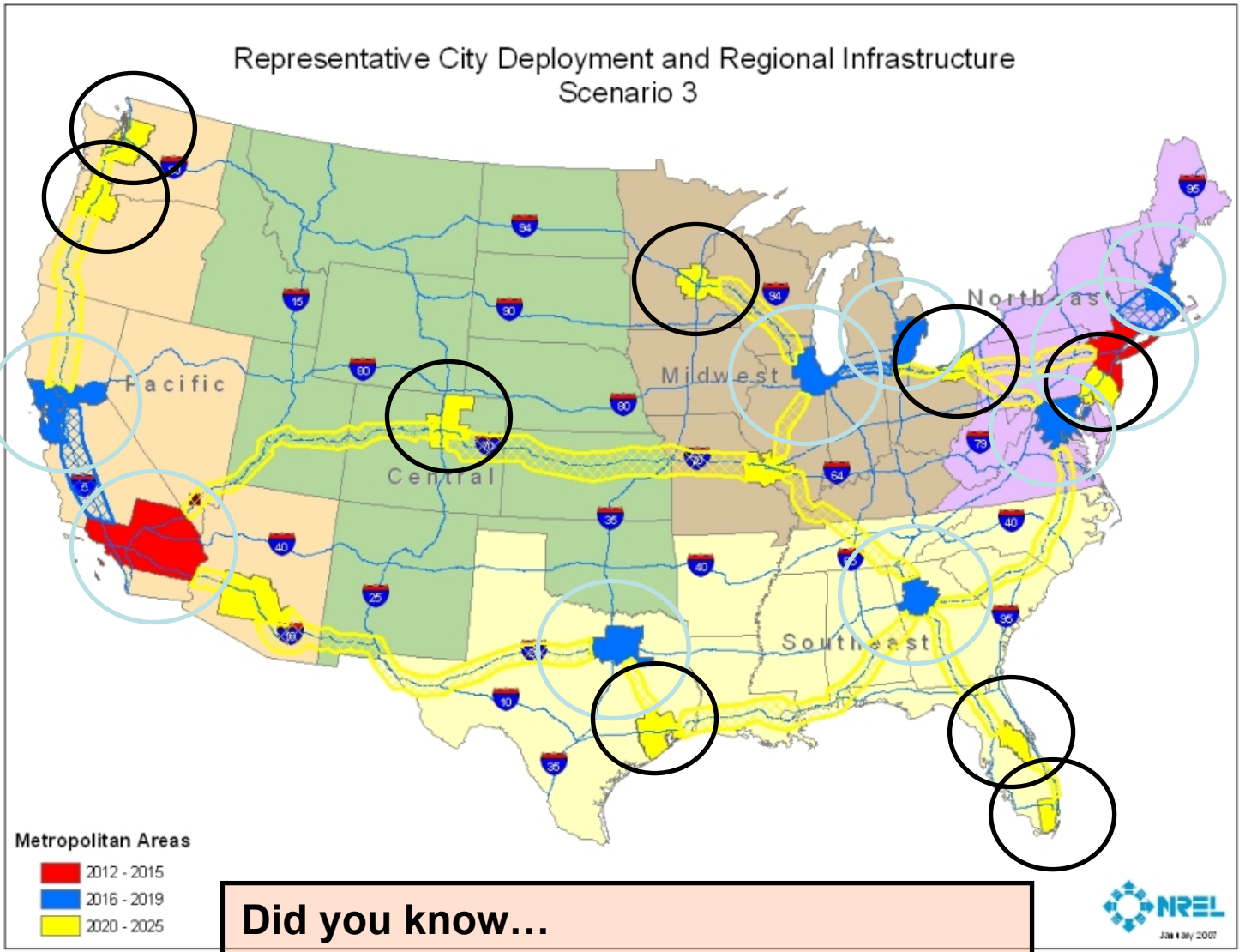
2020-2025: **Inter-regional expansion**

Pipelines become critical

Good $H_2$ demand (LA/NY)

All demand considered

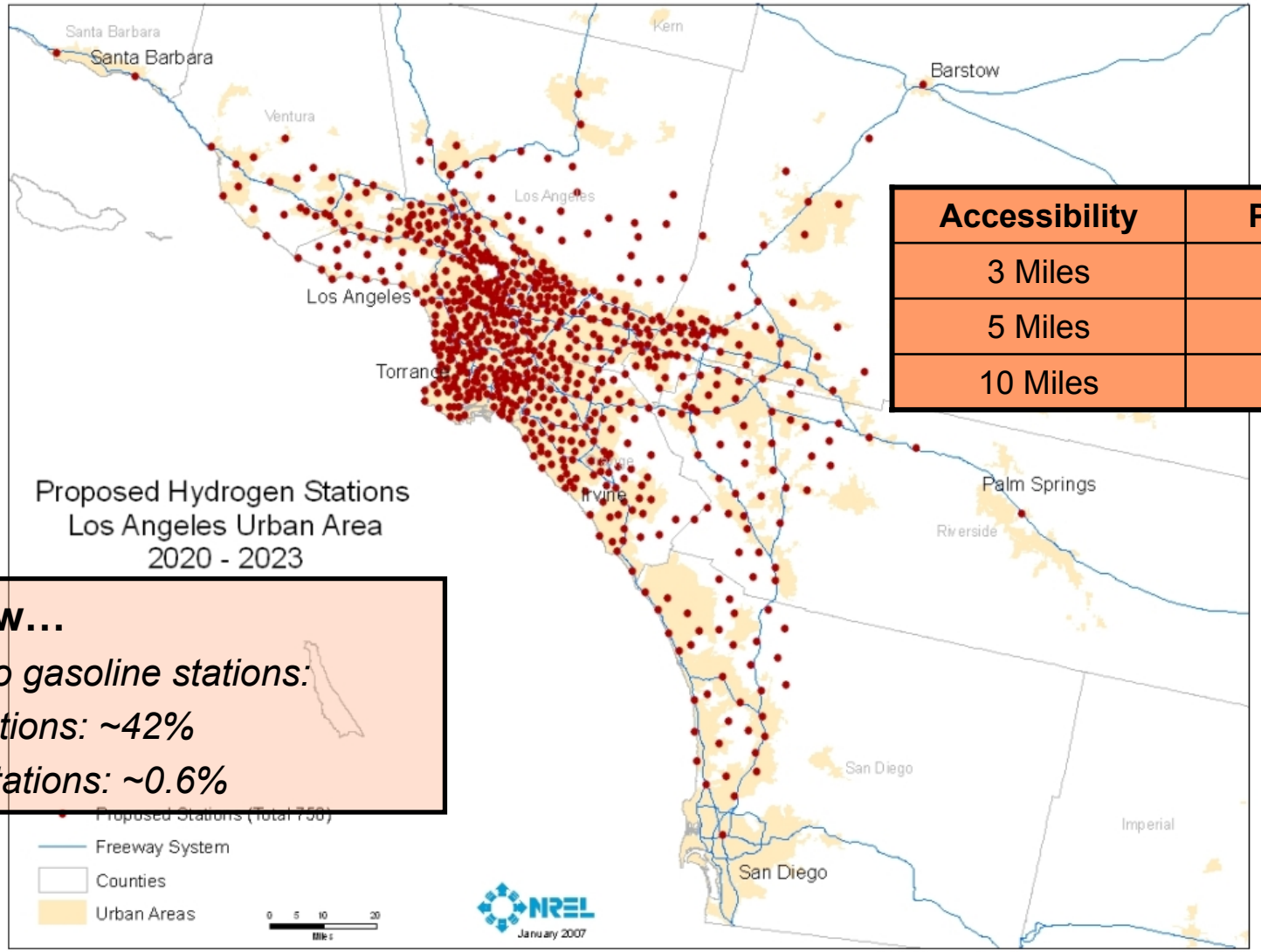
# 2020-2025: Inter-Regional Expansion




**Did you know…**

*Central region represents 7% of U.S. vehicles.*

# 2020-2025: Inter-Regional Expansion - LA




| Accessibility | Population |
|---|---|
| 3 Miles | 83% |
| 5 Miles | 89% |
| 10 Miles | 95% |

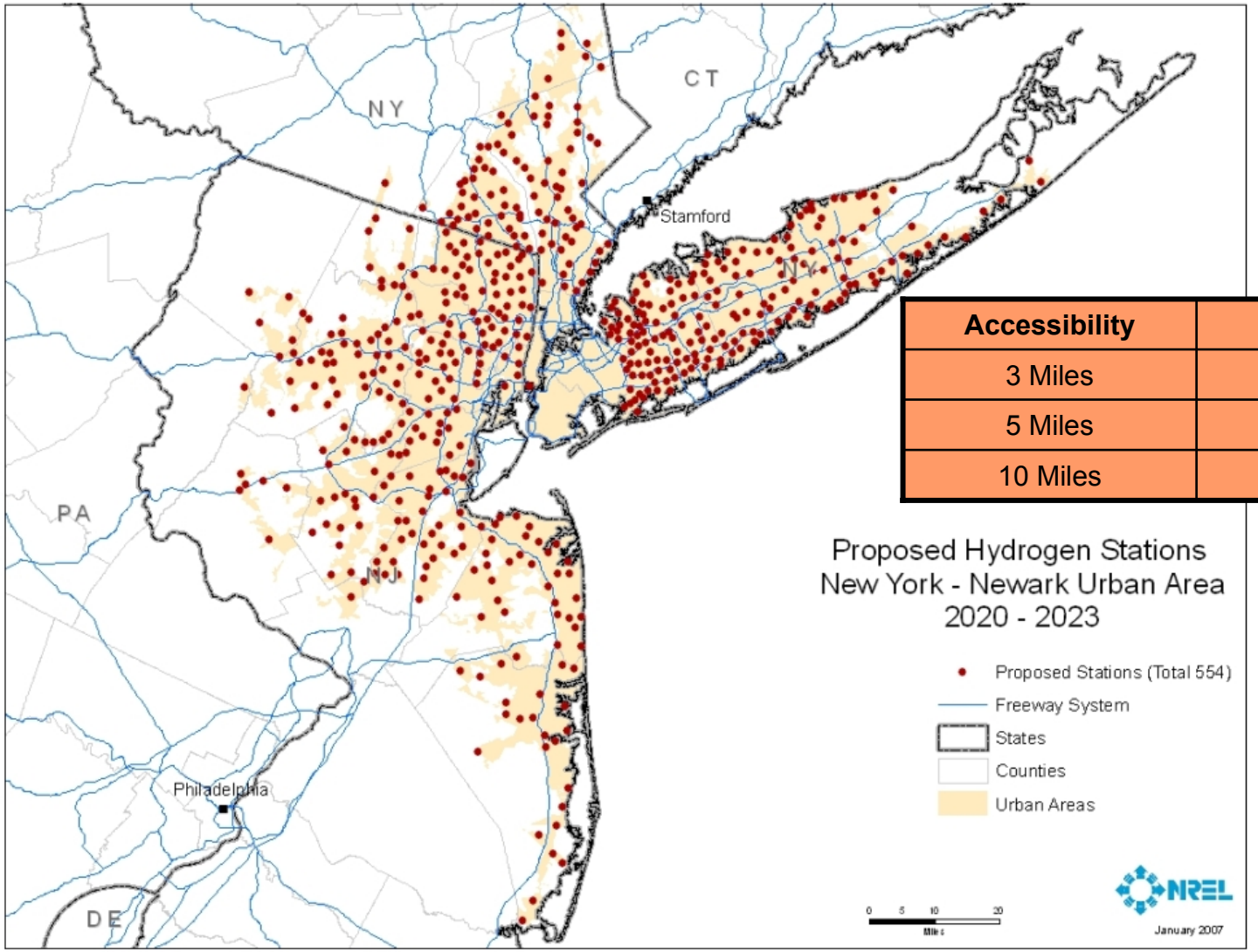
**Did you know…**

*Penetration into gasoline stations:*

*Diesel stations: ~42%*

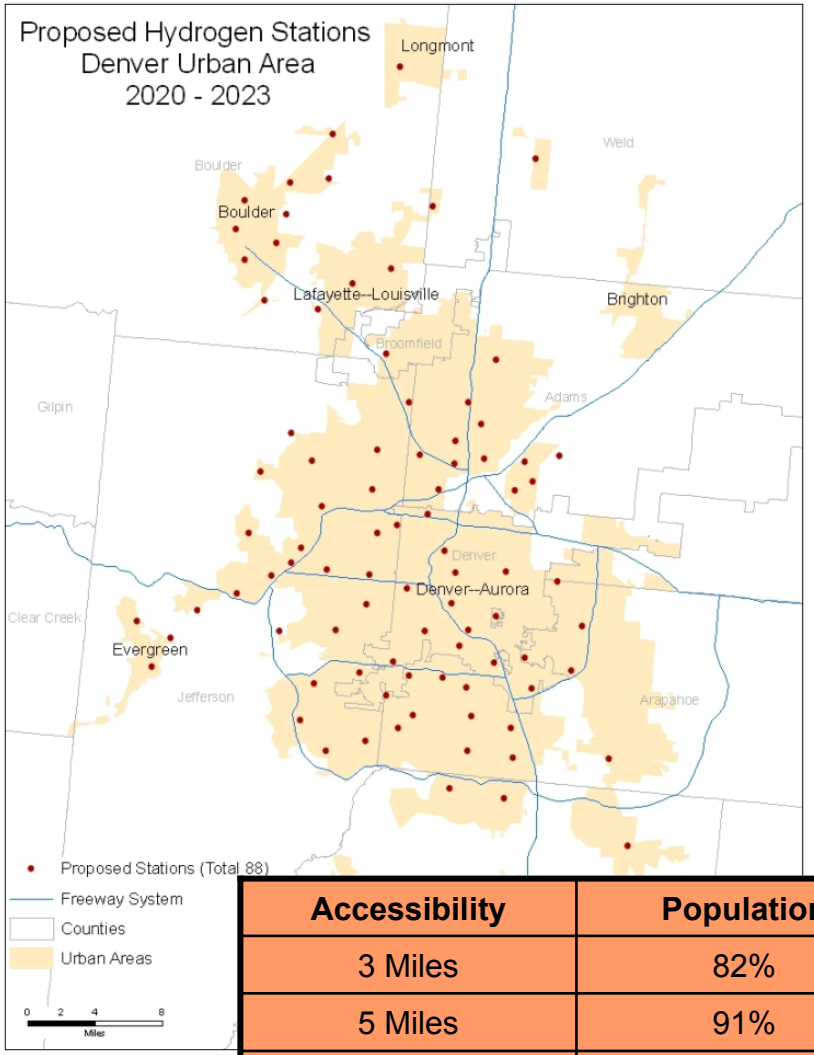
*Ethanol stations: ~0.6%*

# 2020-2025: Inter-Regional Expansion - NY




| Accessibility | Population |
|---|---|
| 3 Miles | 80% |
| 5 Miles | 88% |
| 10 Miles | 95% |

# 2020-2025: Inter-Regional Expansion - Denver and Minneapolis

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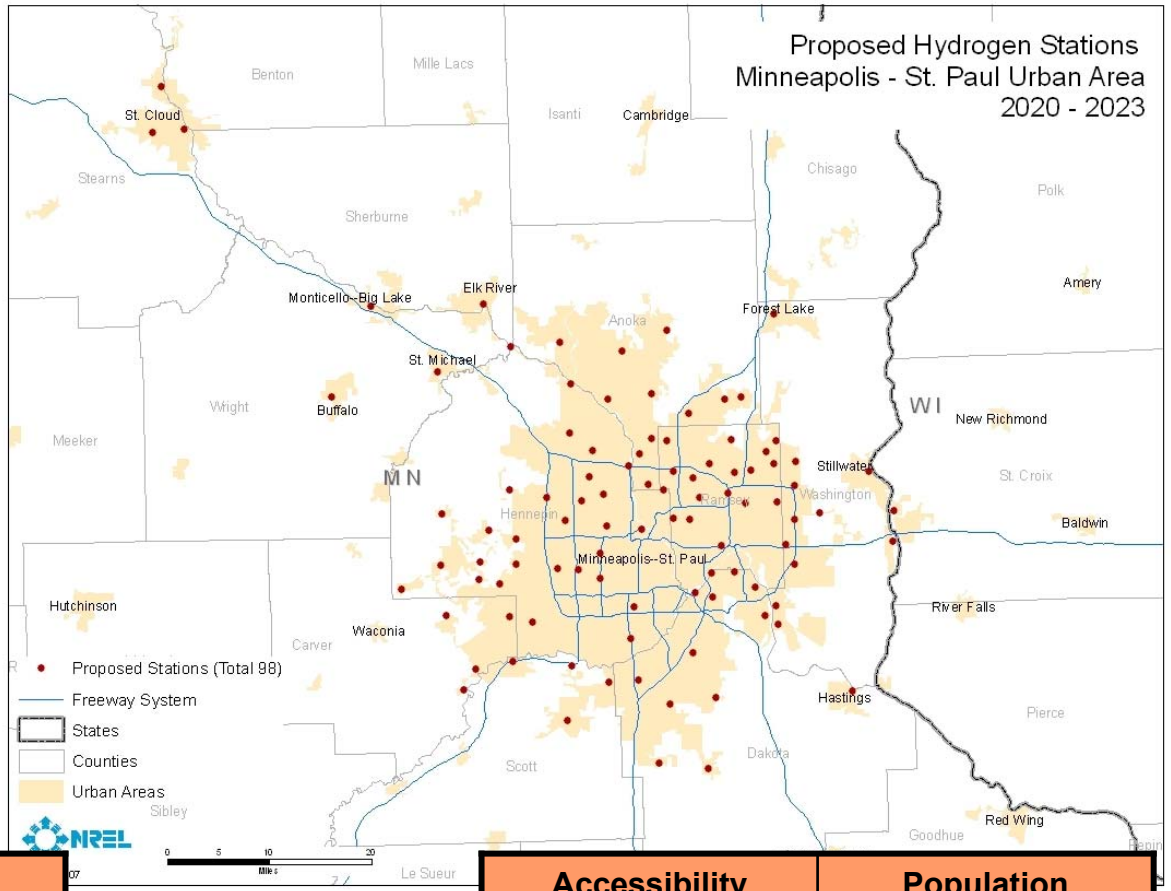
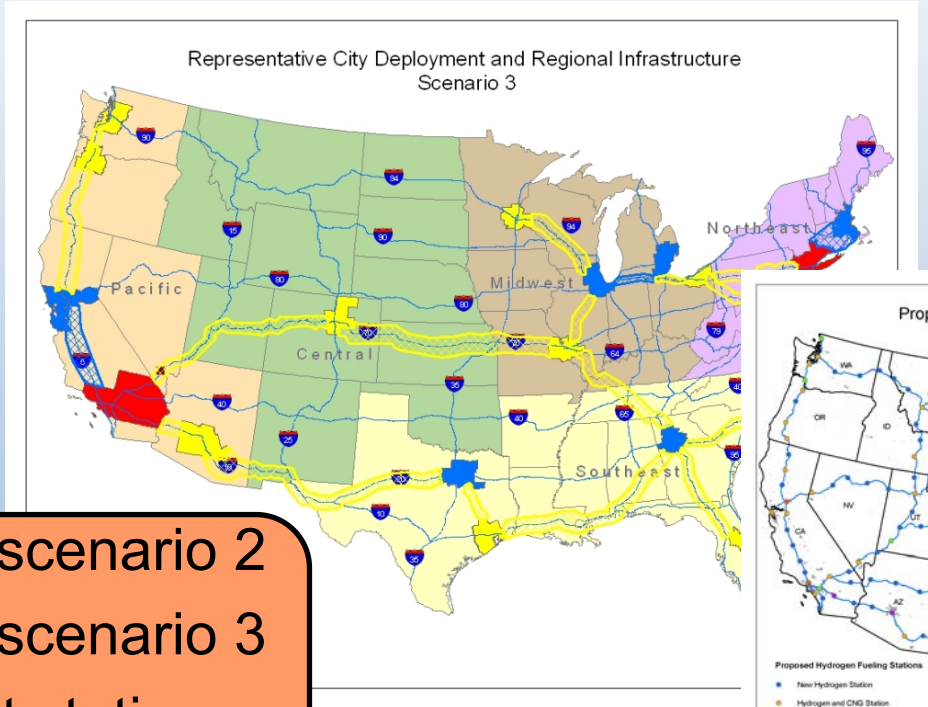
| 3 Miles | 82% |
| 5 Miles | 91% |
| 10 Miles | 96% |

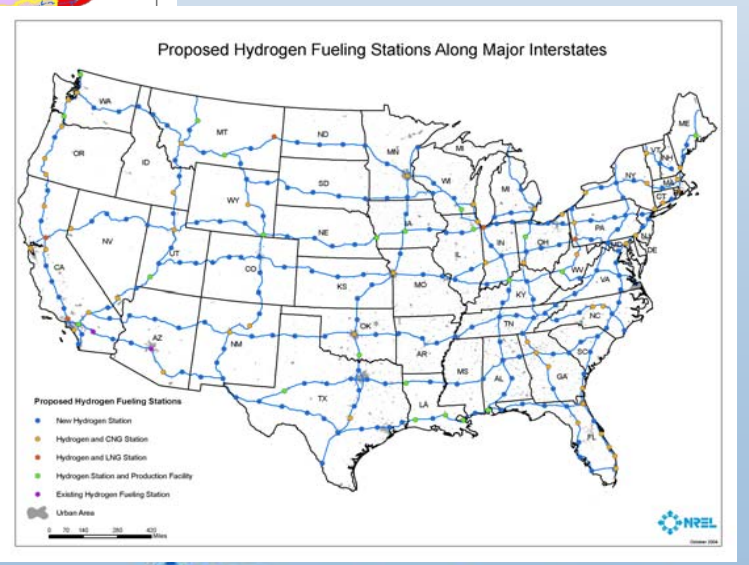



| Accessibility | Population |
|---|---|
| 3 Miles | 78% |
| 5 Miles | 93% |
| 10 Miles | 99% |

# 2021-2025: Widespread Utilization in Scenario 3

- 15%+ of existing gasoline stations in key cities
- Connecting stations enable inter-regional transport
- Focus on pipeline distribution




4,000 stations in scenario 2

8,000 stations in scenario 3

~85 interconnect stations

~200 other interstate stations

# Project Summary

- Each geographic location has distinctive properties that make infrastructure unique
- Strategically placing stations maximizes coverage early
- Rollouts are very aggressive, but at 7% to 15% there is adequate coverage for transition (based on 3, 5, and 10 mile travel distances)