Geographically-Based Hydrogen Demand & Infrastructure Rollout Scenario Analysis

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May 17, 2007

Project # TVP2

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

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

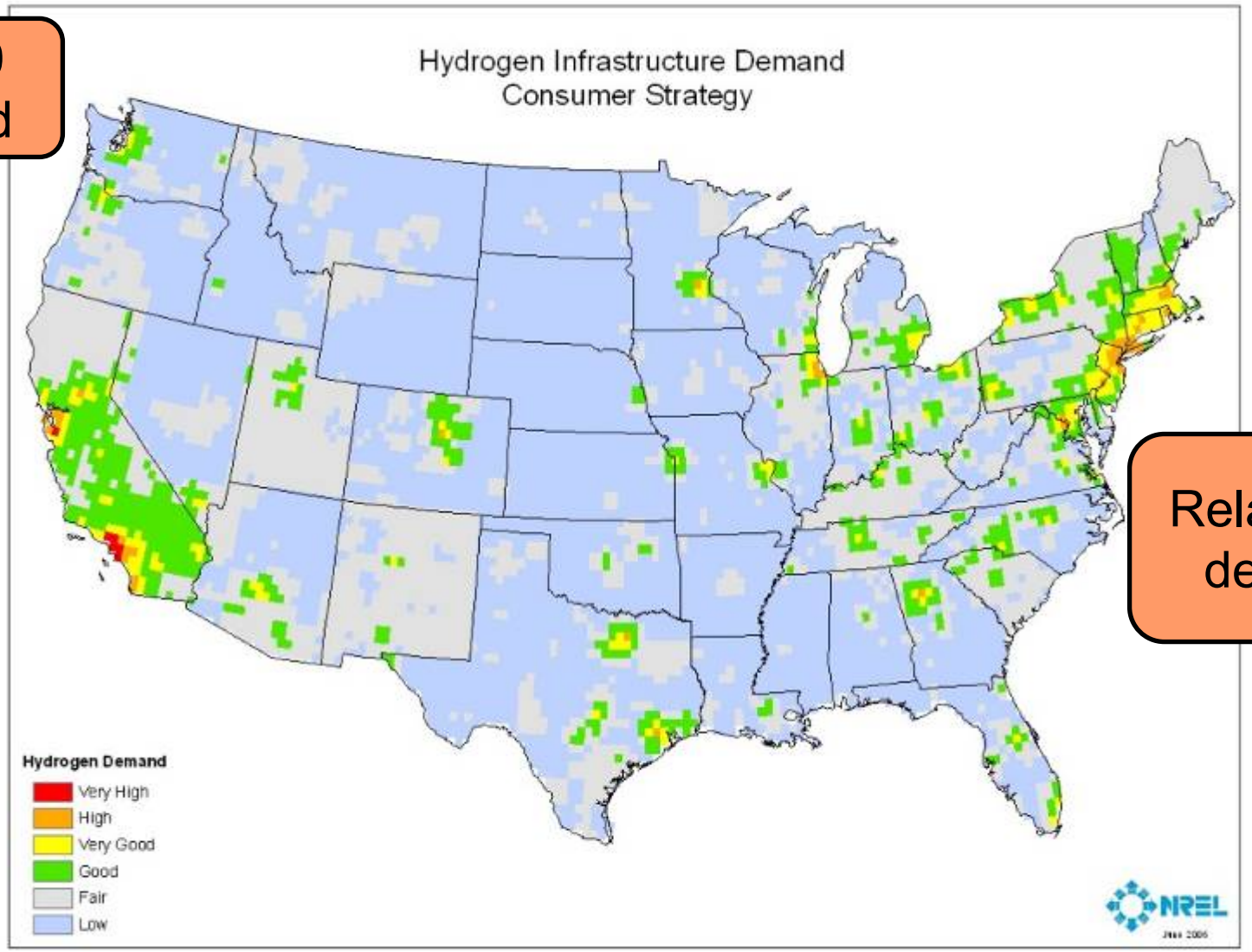
2020-2025: Inter-regional expansion

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

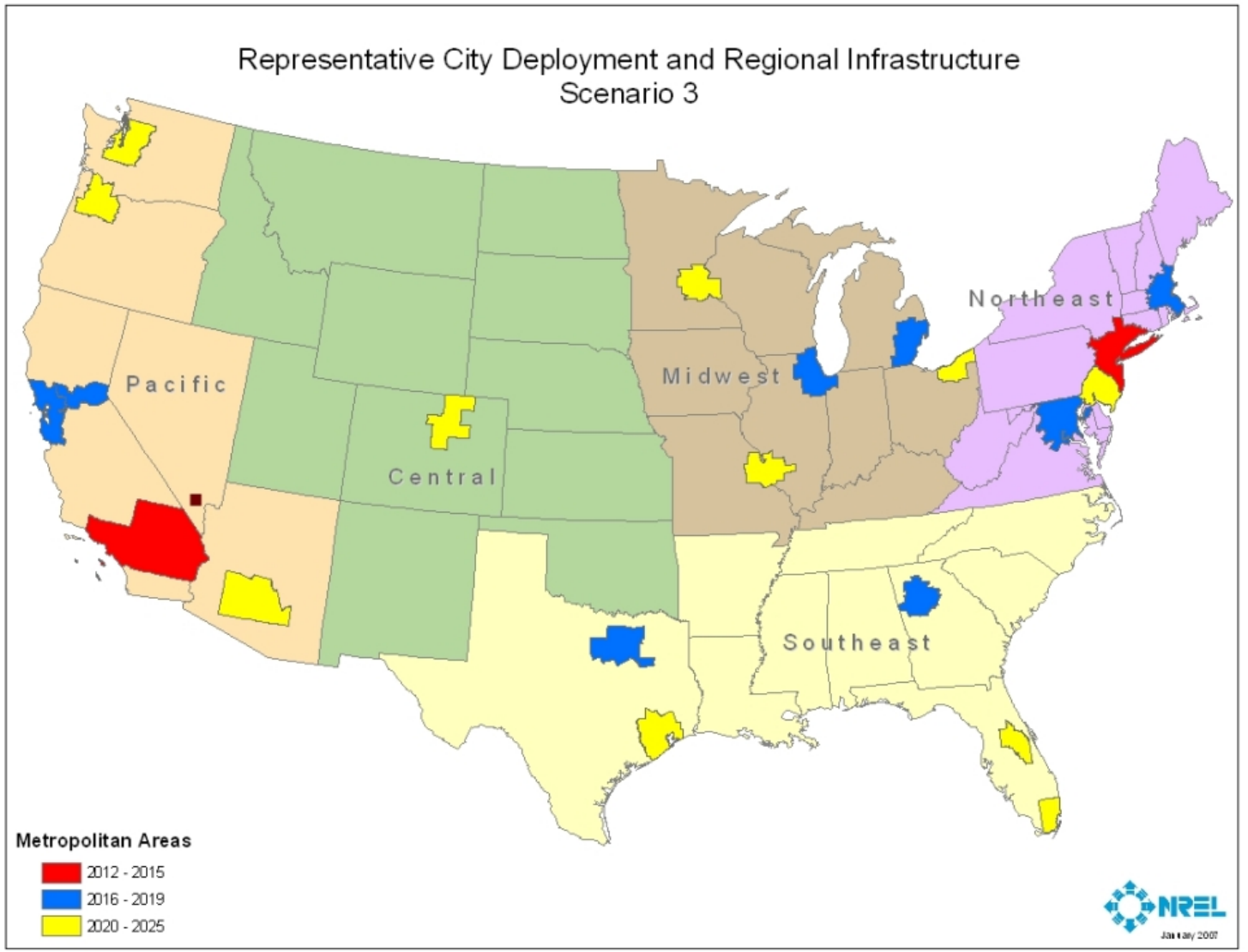
- Fleets sustain fuel market; consumers sustain vehicle markets
- Coordination is vital
  - Infrastructure and vehicle deployment
- Incentives and mandates are both important
  - Right ones
  - Right time
- Backing from agencies necessary
  - Fire, safety, permitting, insurance
- Local level efforts 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 Limited Cities	<100 Stations	~200 Stations	~1,500 Stations
Scenario 2 All 20 Cities	<100 Stations	~1,200 Stations	~4,000 Stations
Scenario 3 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

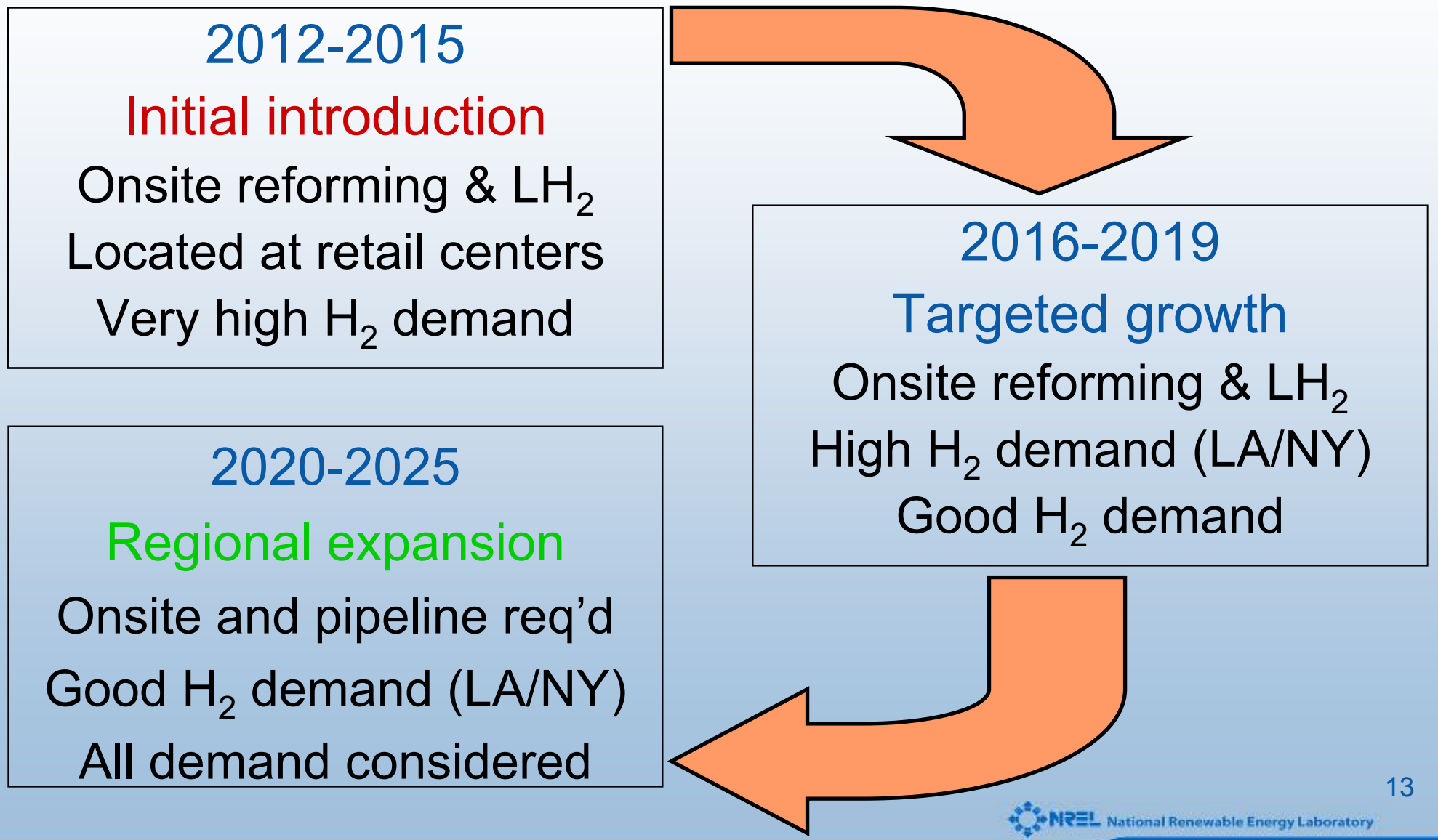
Infrastructure Rollout

Urban Area	2012-2015 Stations	2016-2019 Stations	Scenario 2 2020-2025 Stations	Scenario 3 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%

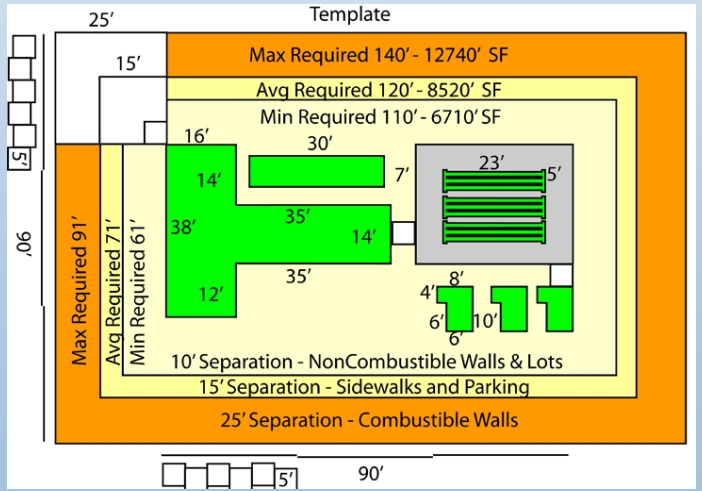
Infrastructure Strategy



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

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

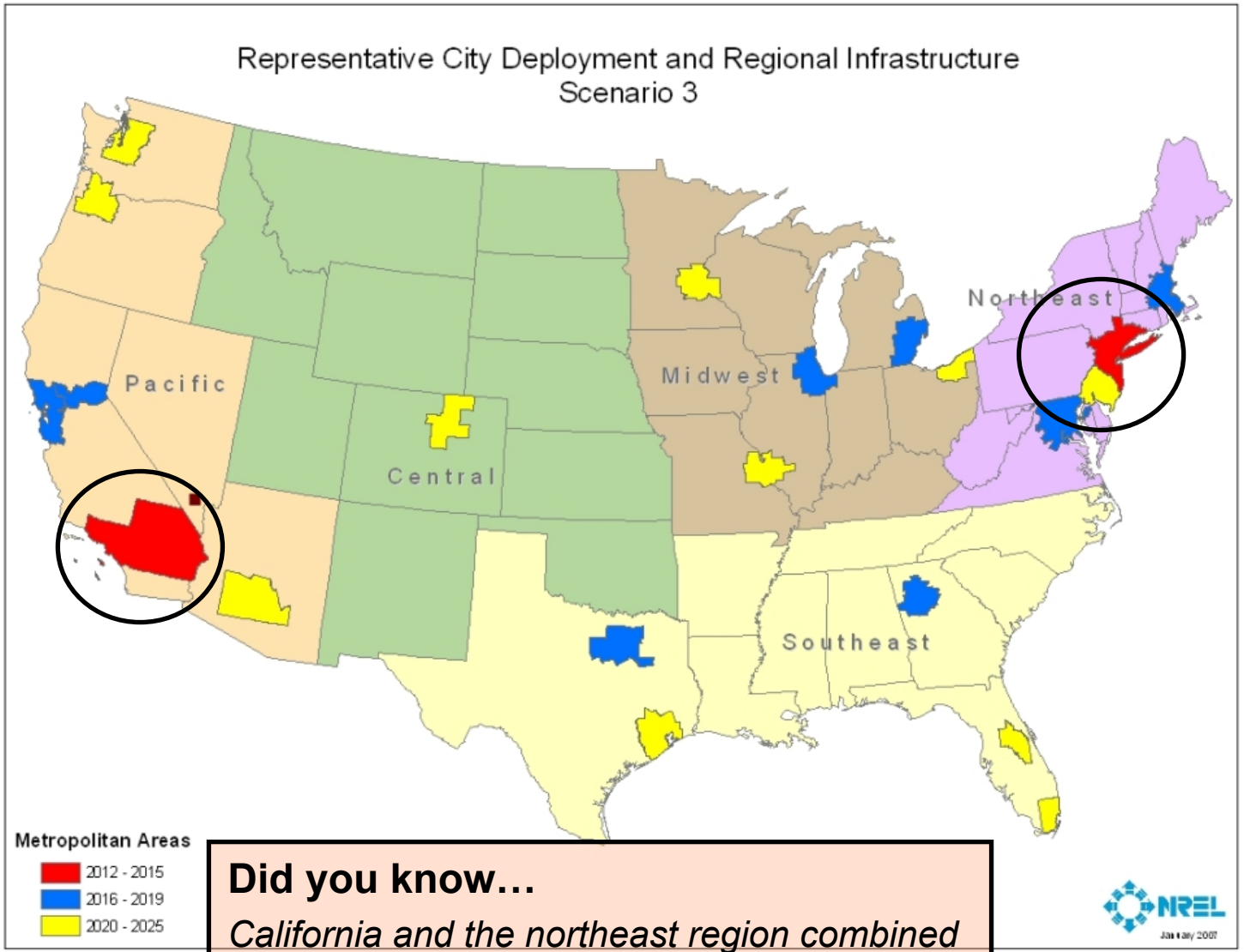
2012-2015: Initial introduction

Onsite reforming & LH_2 focus

Located at retail centers

Very high H_2 demand

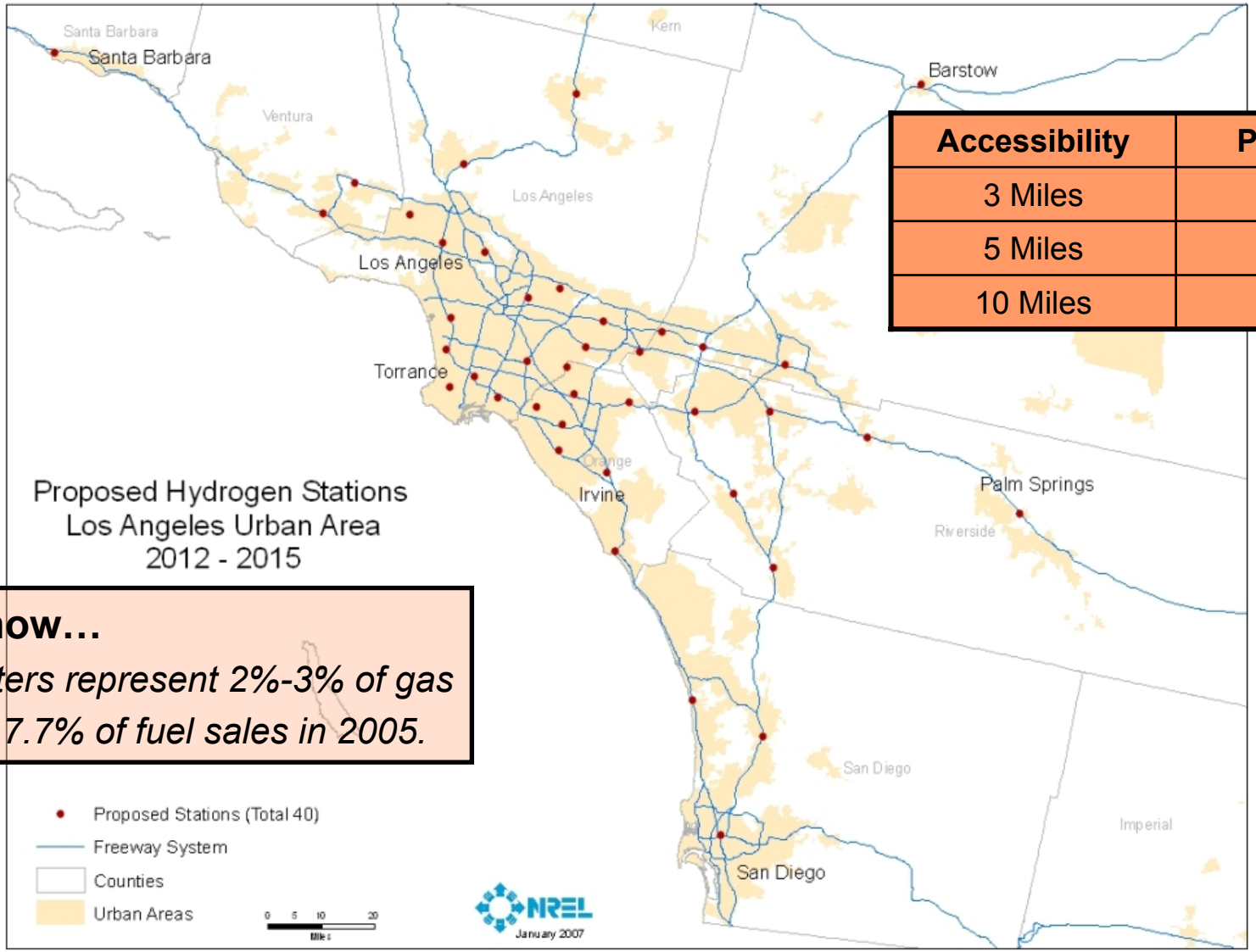
2012-2015: Initial Introduction



Did you know…

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

2012-2015: Initial Introduction - LA

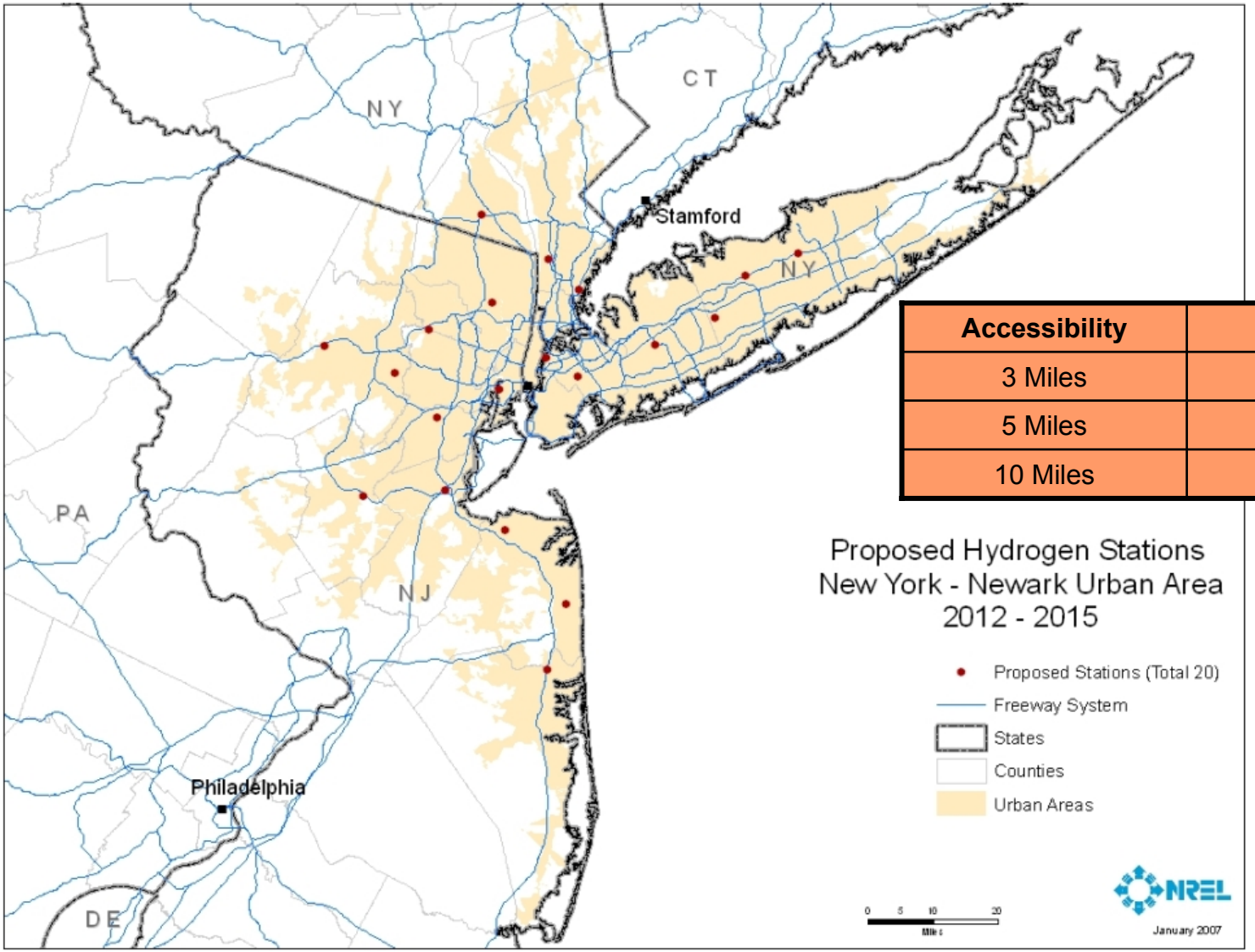


Accessibility	Population
3 Miles	23%
5 Miles	51%
10 Miles	88%

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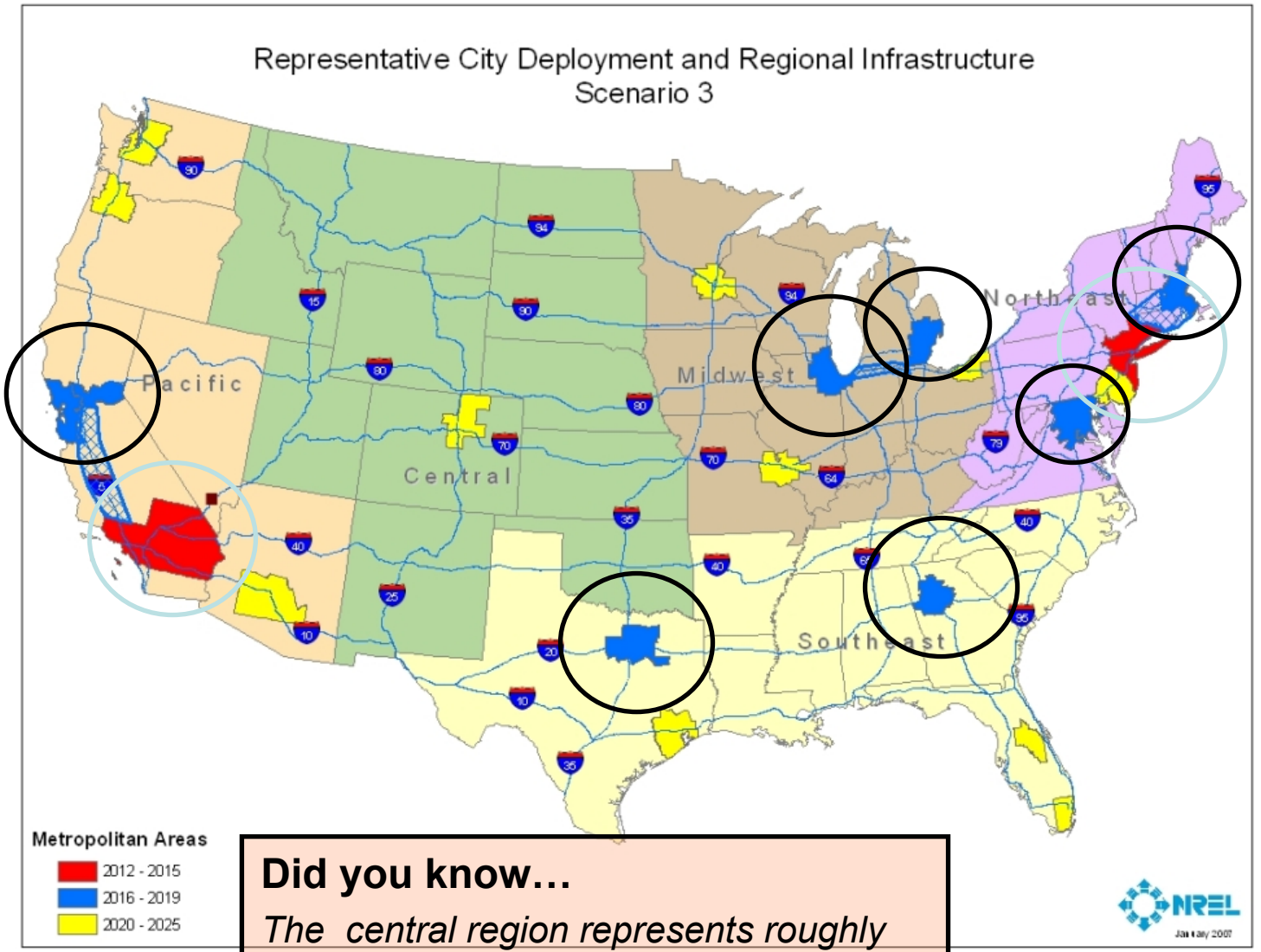
2016-2019: Targeted growth
Onsite reforming & LH_2 focus
High H_2 demand (LA/NY)
Good H_2 demand

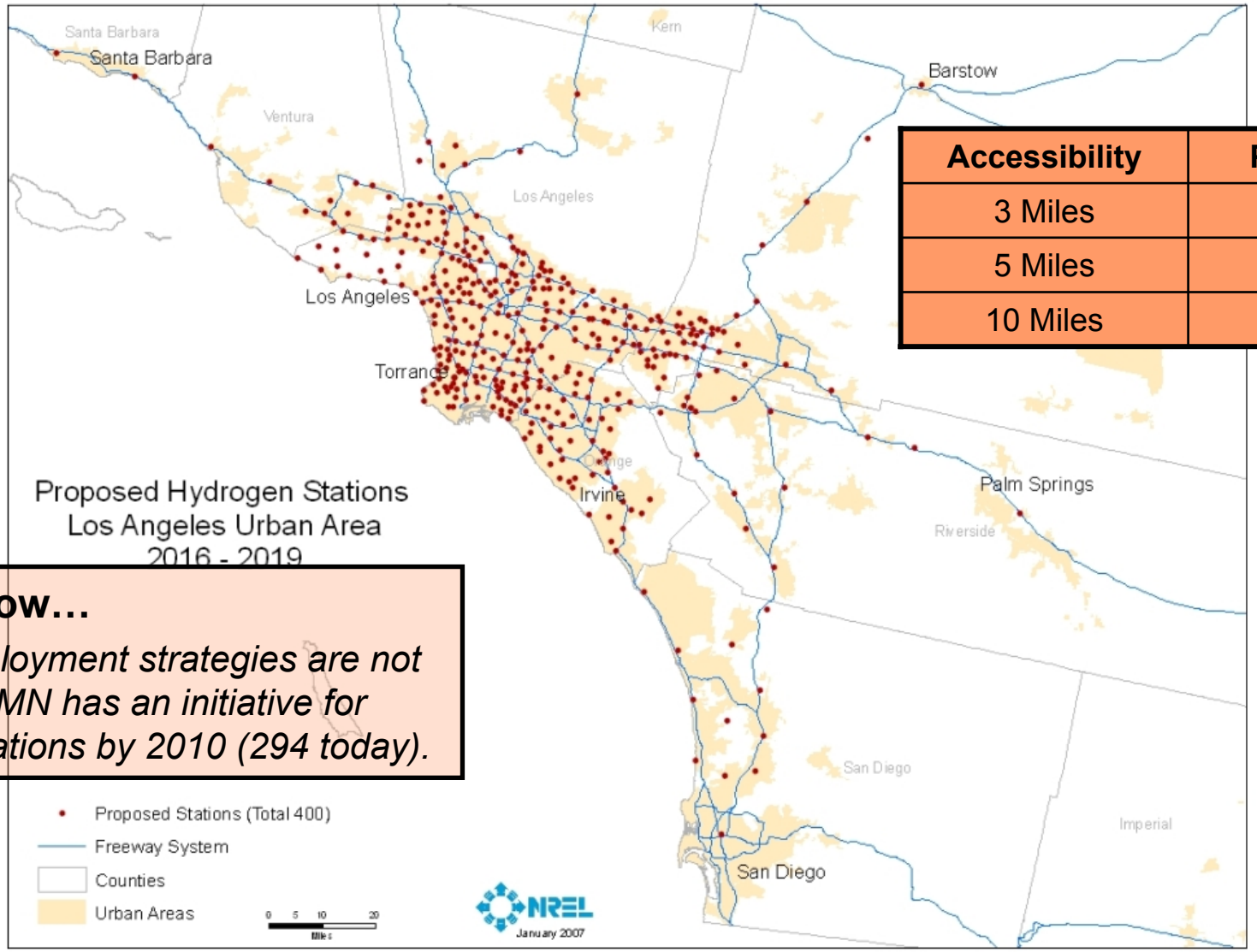
2016-2019: Targeted Growth



Did you know…

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

2016-2019: Targeted Growth - LA

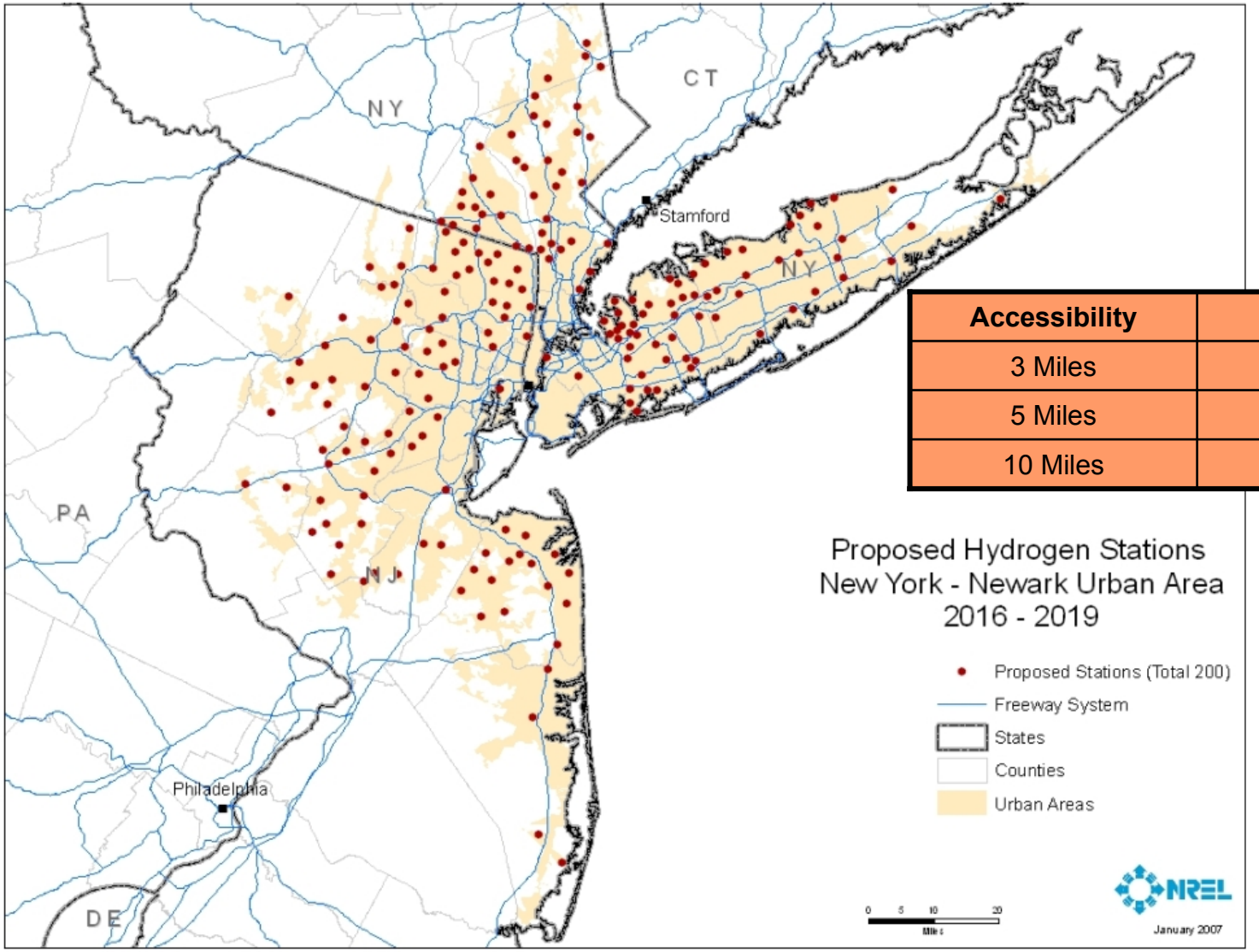


Accessibility	Population
3 Miles	73%
5 Miles	83%
10 Miles	94%

Did you know…

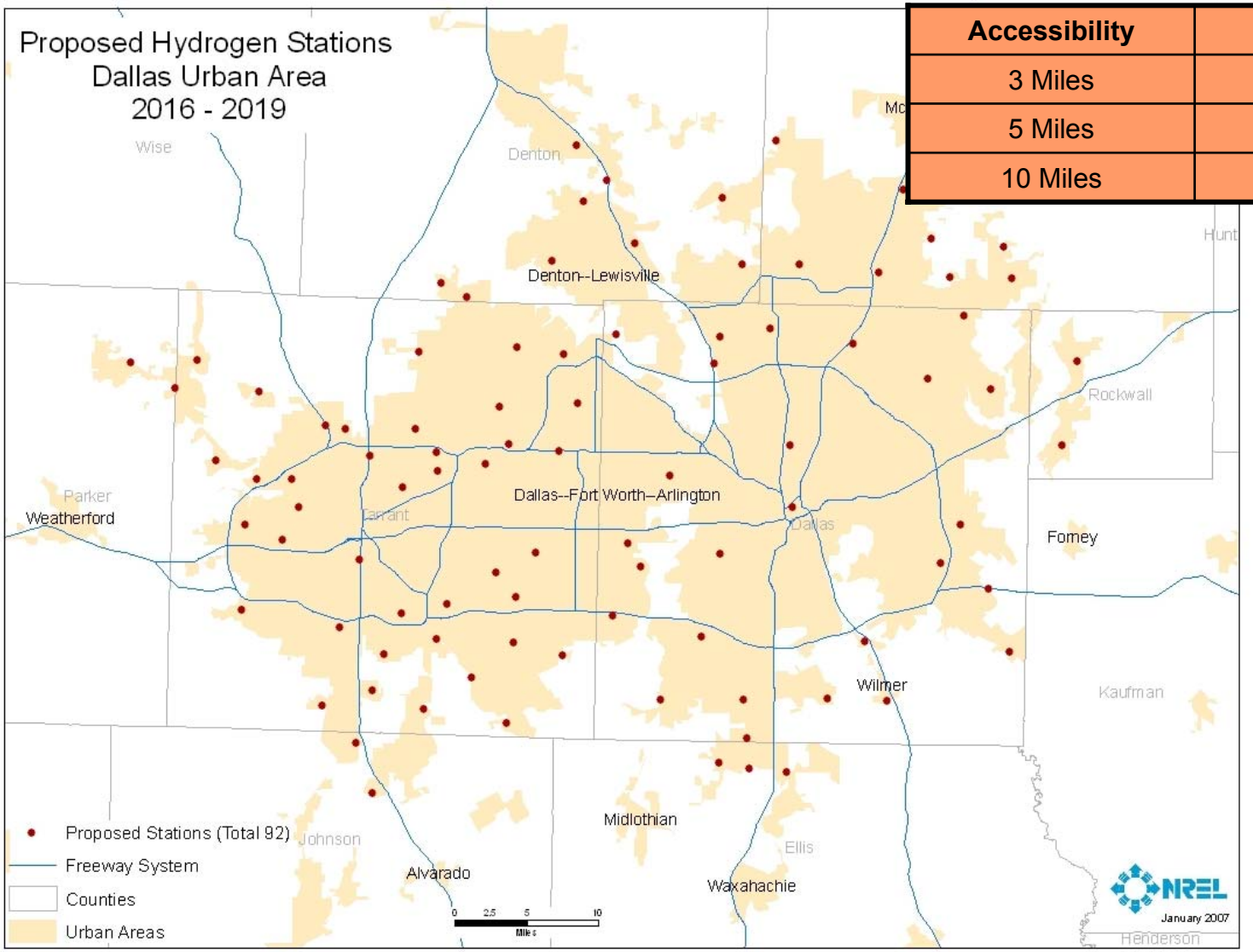
Targeted deployment strategies are not uncommon. MN has an initiative for 1,800 E85 stations by 2010 (294 today).

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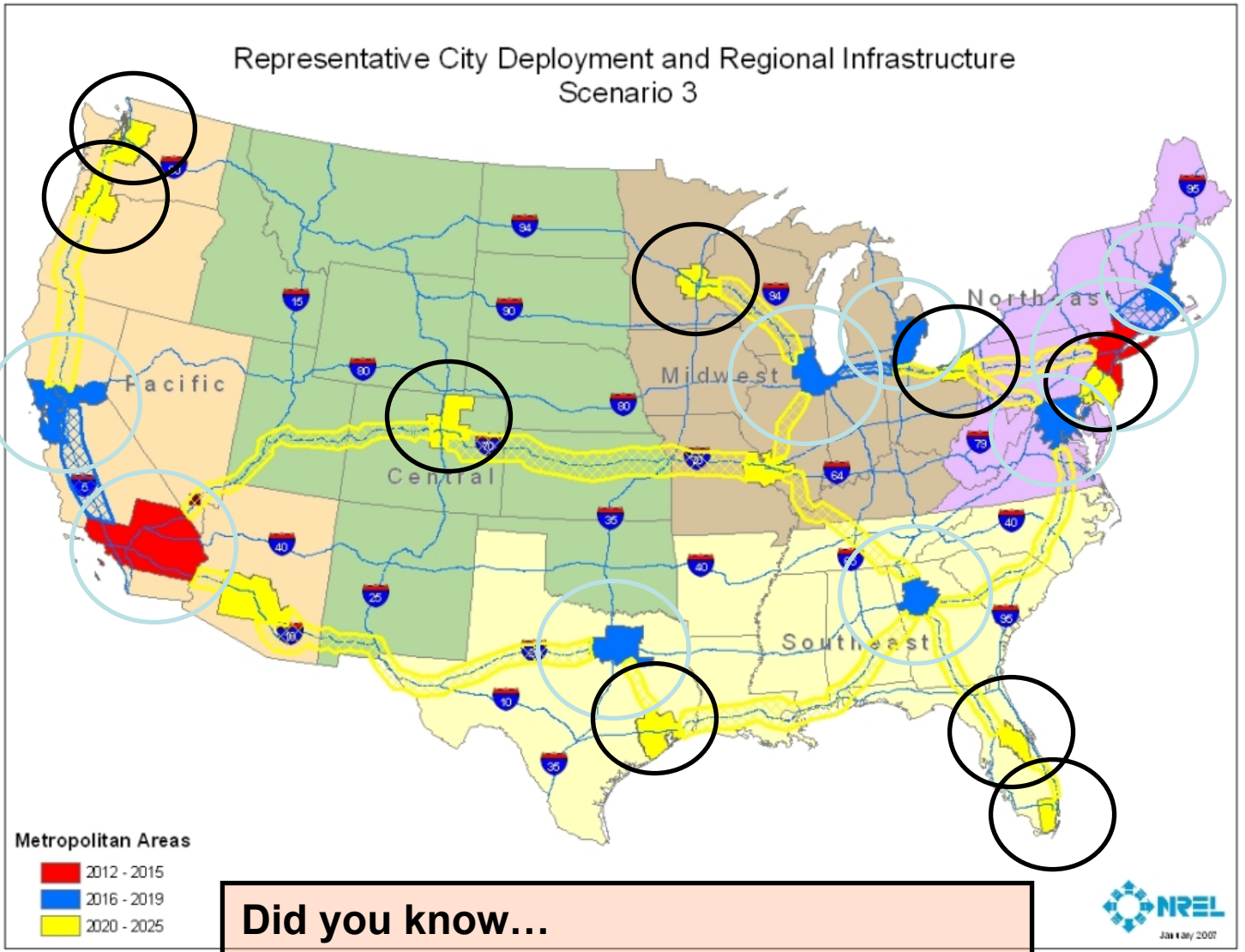
2020-2025: **Inter-regional expansion**

Pipelines become critical

Good H_2 demand (LA/NY)

All demand considered

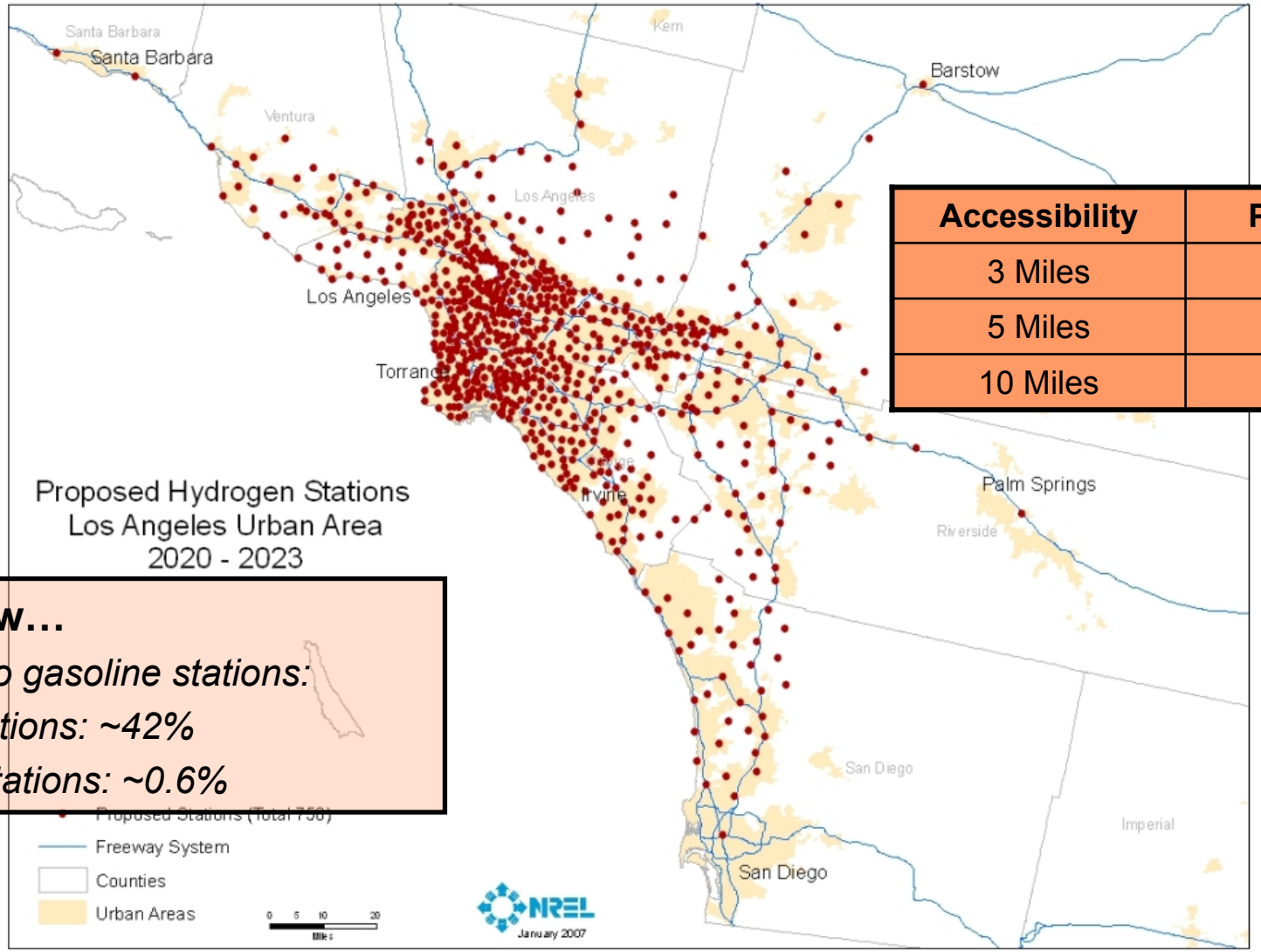
2020-2025: Inter-Regional Expansion



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%

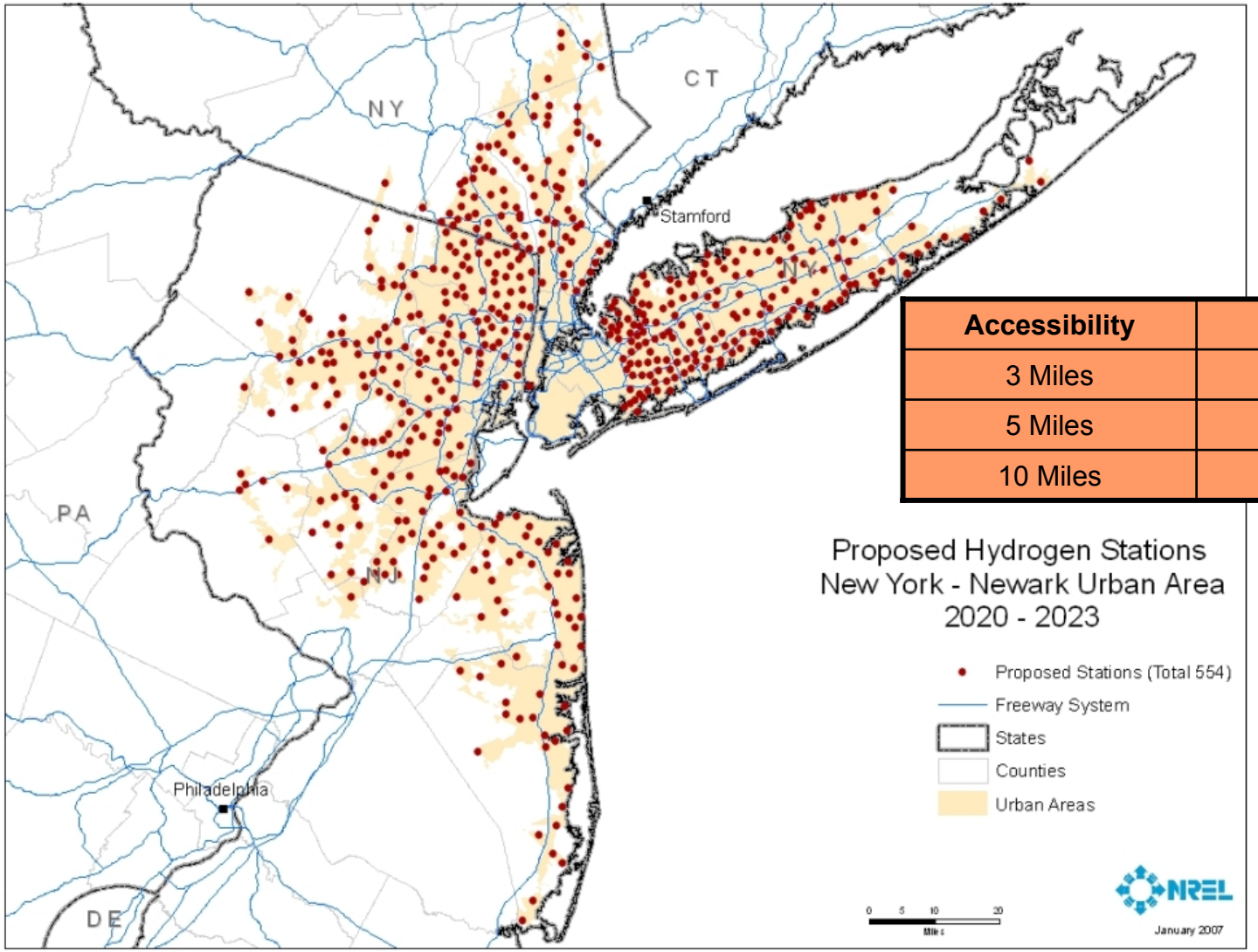
Did you know…

Penetration into gasoline stations:

Diesel stations: ~42%

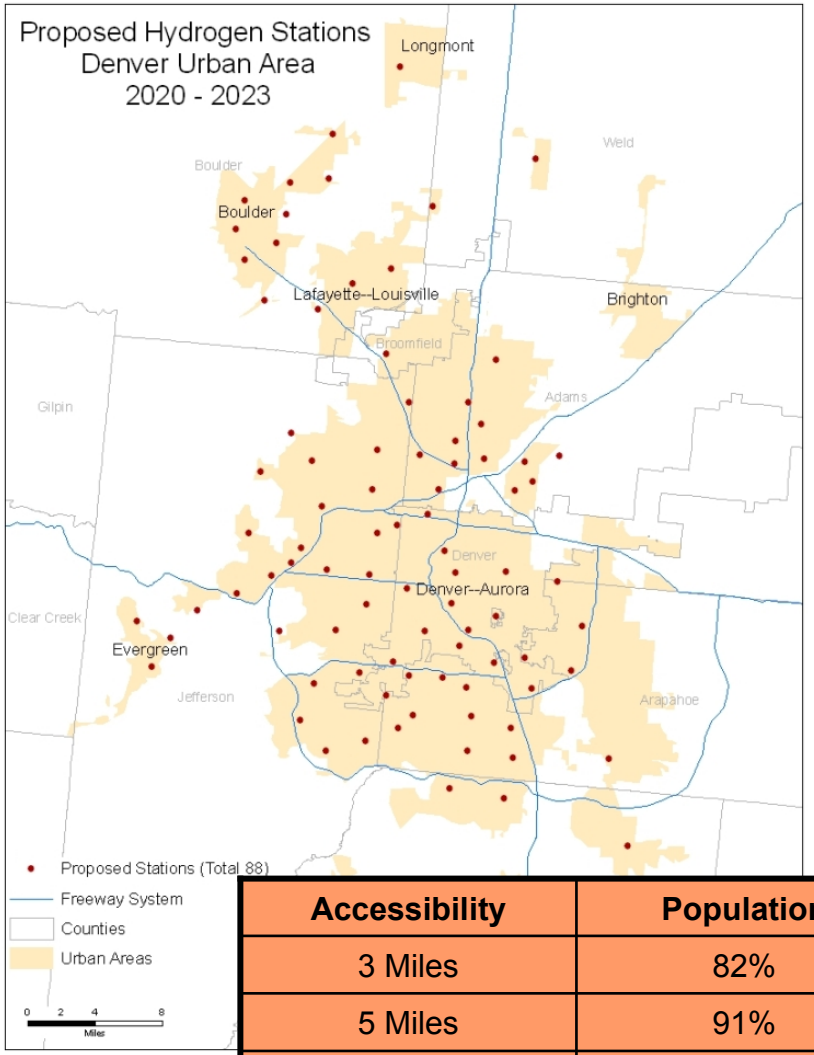
Ethanol stations: ~0.6%

2020-2025: Inter-Regional Expansion - NY

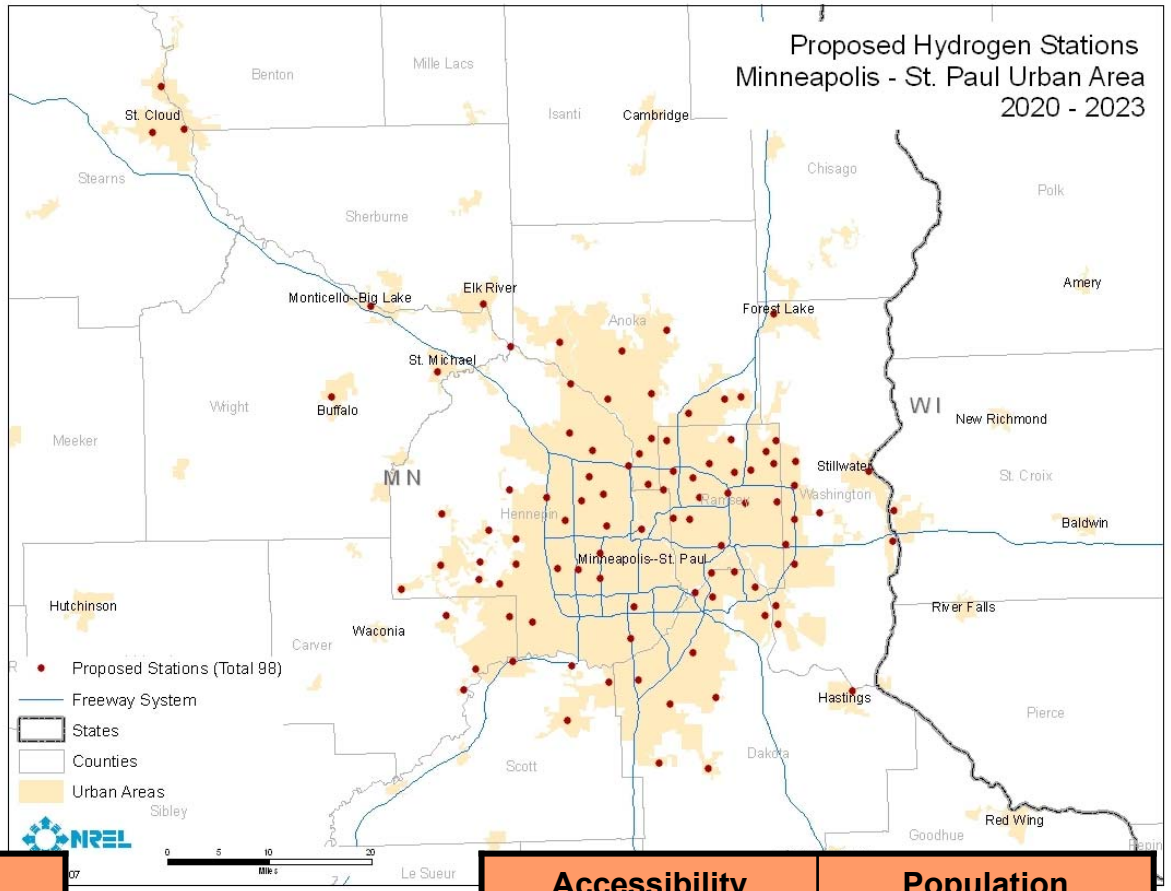


Accessibility	Population
3 Miles	80%
5 Miles	88%
10 Miles	95%

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



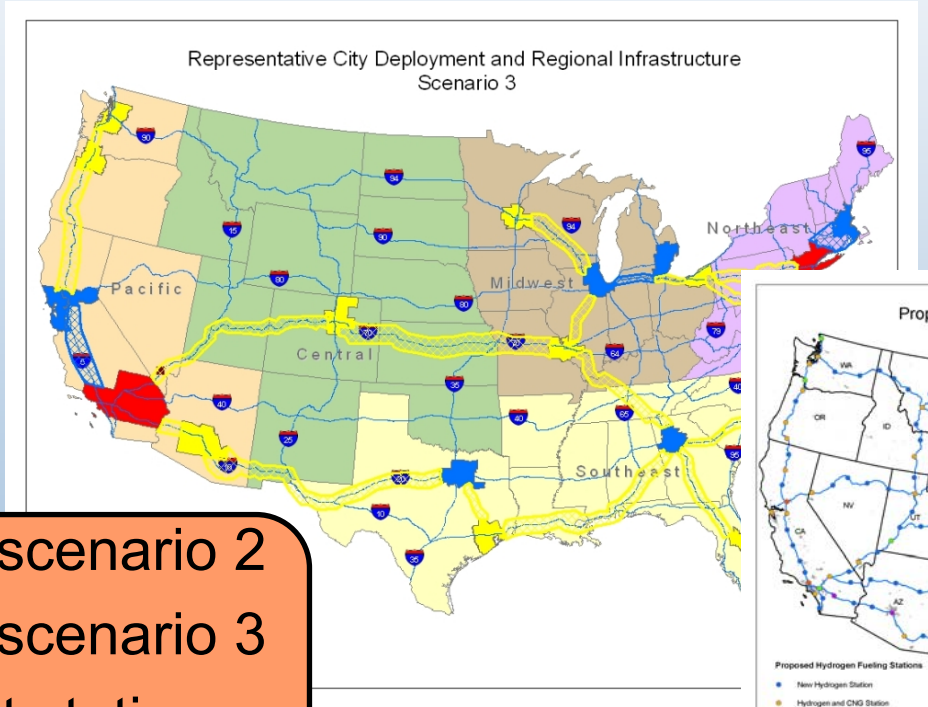
Accessibility	Population
3 Miles	82%
5 Miles	91%
10 Miles	96%

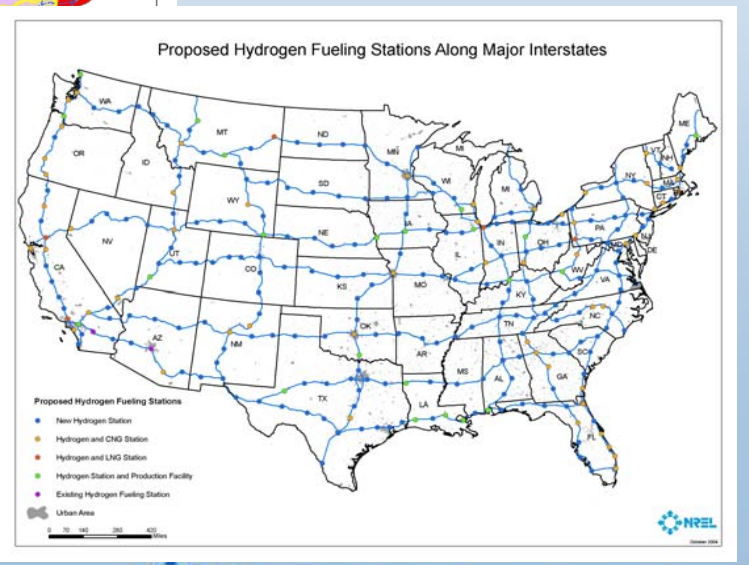


Accessibility	Population
3 Miles	78%
5 Miles	93%
10 Miles	99%

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)