

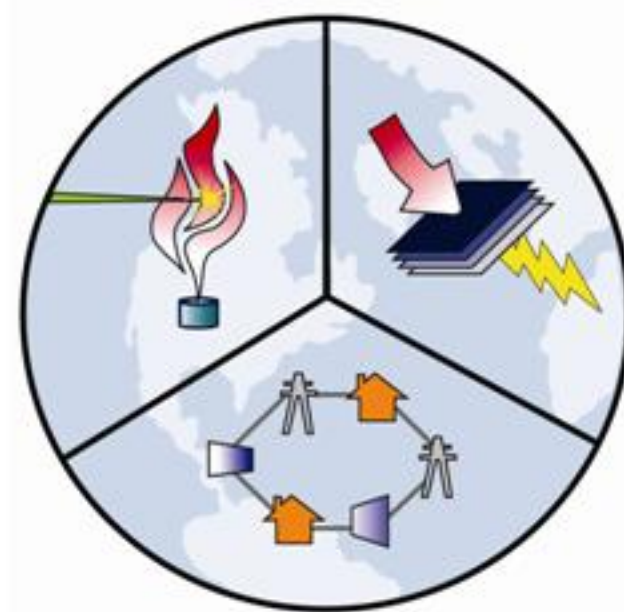
A Strategic Plan to Optimize Locations for California Hydrogen Fueling Stations

California Energy Commission

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Advanced Power and Energy Program
University of California, Irvine
Dr. Tim Brown

Presentation to the California Energy Commission
June 22, 2012

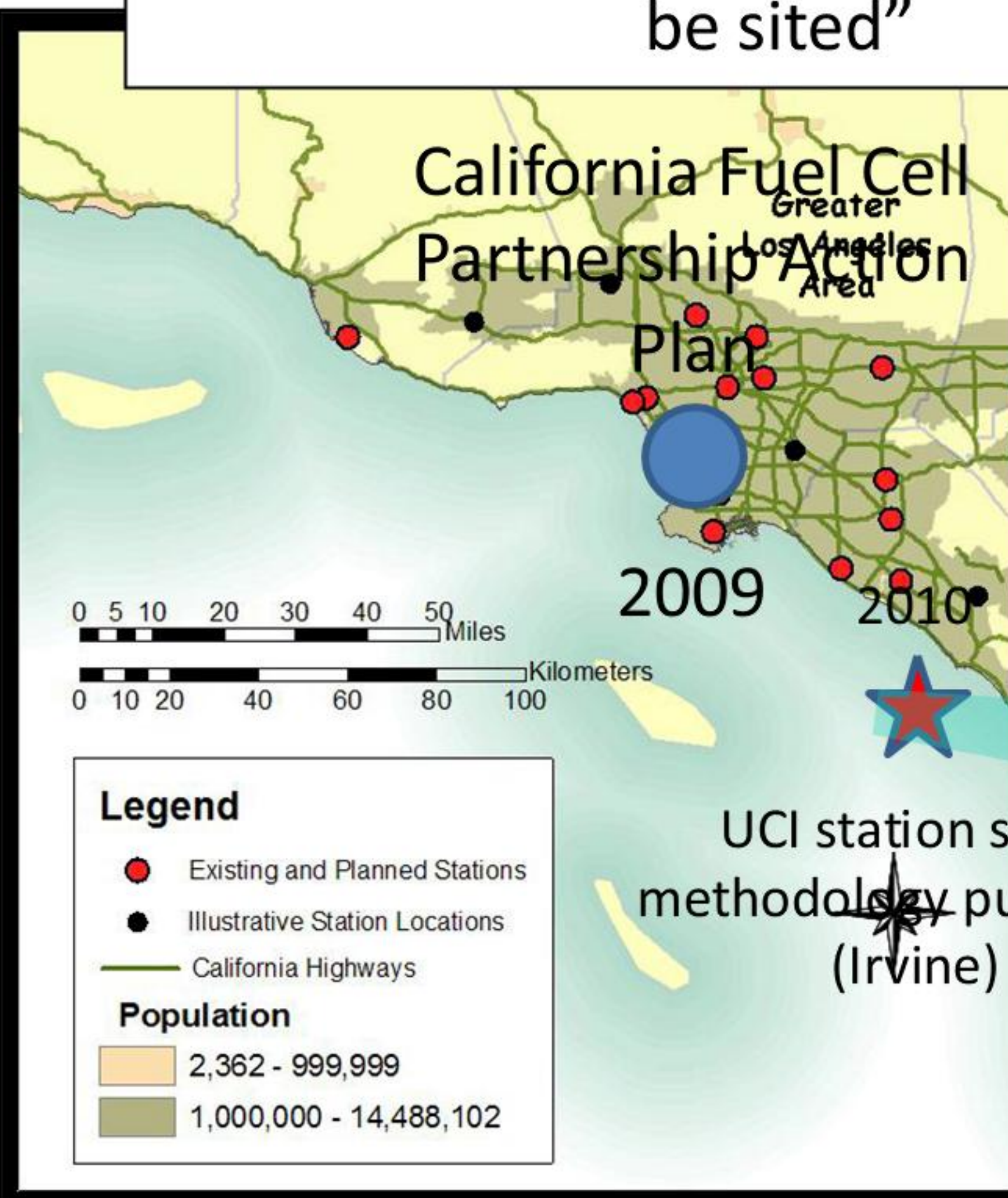
Workshop Questions

- What defines the optimal hydrogen station location?
- What is the best approach for selecting site locations for stations in the future?

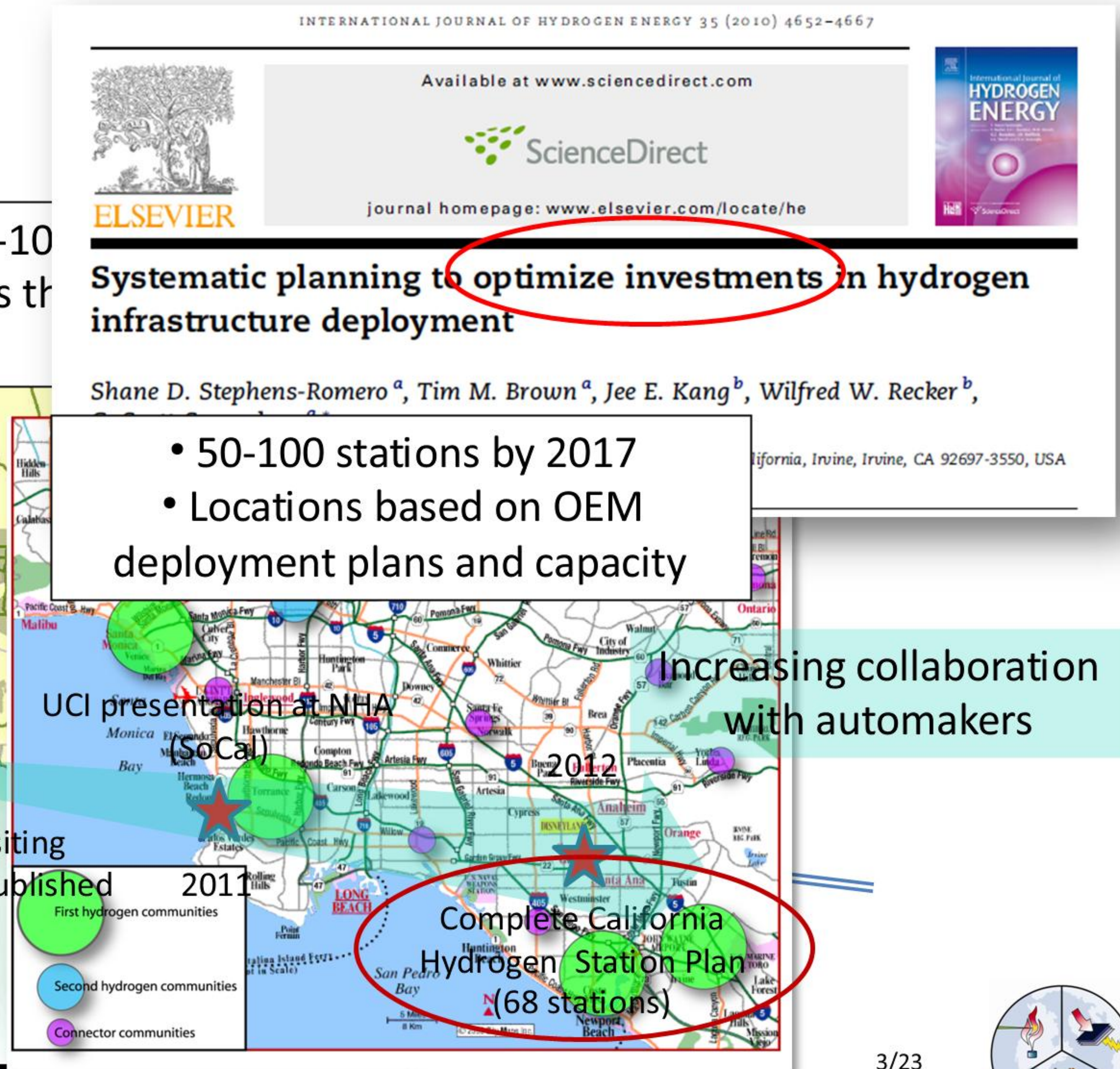


History of California H₂ Infrastructure Planning

- Phase 1 infrastructure: 50-100
- Maps showed stations “as they be sited”



UCI station siting methodology published (Irvine)



Extensive Automaker Collaboration

Extensive collaboration between UC Irvine and six automakers over the past year and a half to develop a comprehensive hydrogen station plan for California designed to meet the **coverage** required for initial commercial deployments

- Toyota
- General Motors
- Honda
- Mercedes-Benz
- Hyundai/Kia
- Nissan
- California Fuel Cell Partnership (CaFCP)
- Advanced Power and Energy Program (APEP)

Results represent a combination of:

- Automaker data, market, and technology insights
- Analysis using APEP's Spatially and Temporally Resolved Energy and Environment Tool (STREET)



STREET

Spatially and **T**emporally **R**esolved **E**nergy and **E**nvironment **T**ool

Developed by the Advanced Power and Energy Program at UC Irvine

A systematic and highly detailed land-use based methodology to establish and evaluate fuel infrastructure scenarios (e.g., hydrogen, electricity, natural gas, biofuels)

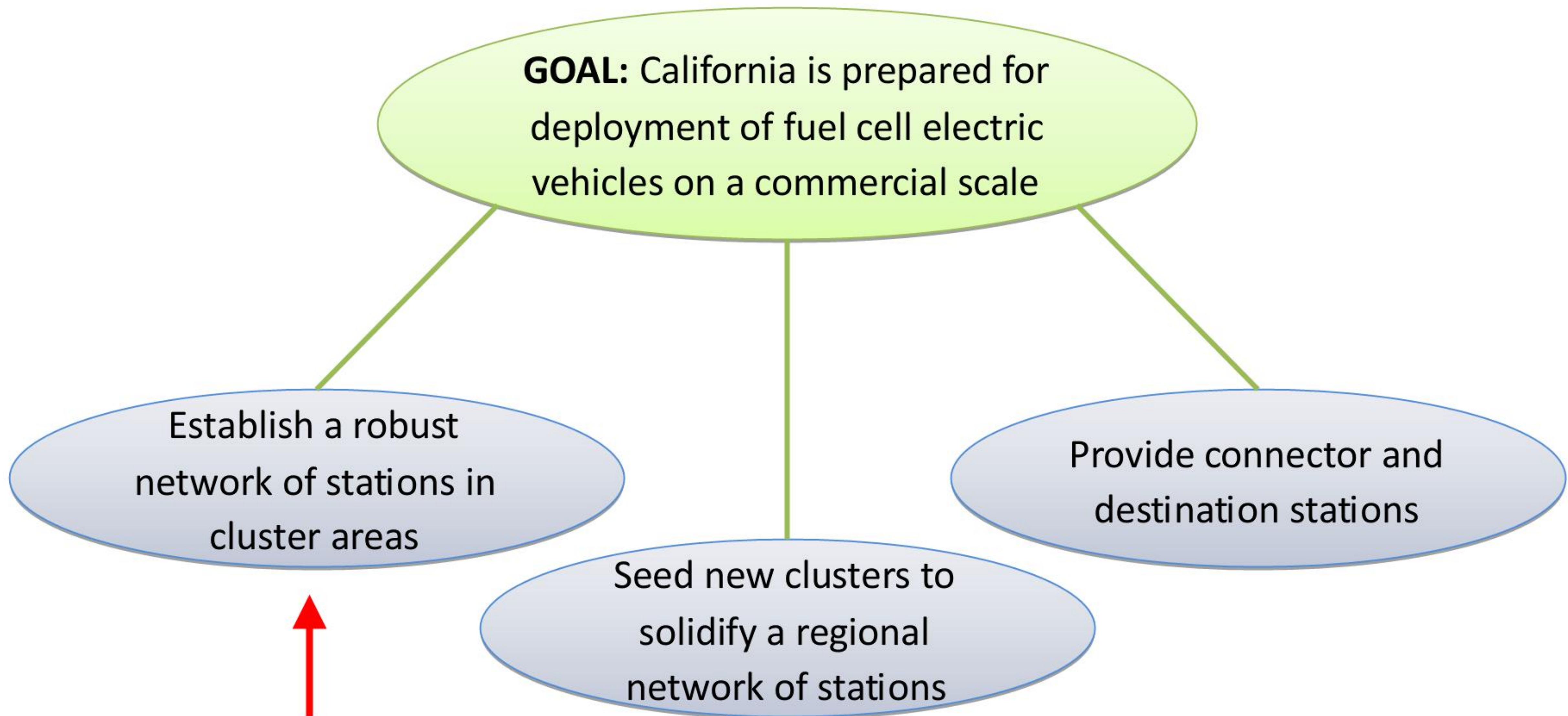
INTEGRATES:

- Fuel Supply Chain Simulations
- Electric Power Generation Simulations
- Geographic Information Systems Data
- Land Use & Infrastructure Considerations
- Traffic Behavior
- Future Vehicle Projections
- Market Information
- Air Quality Simulations

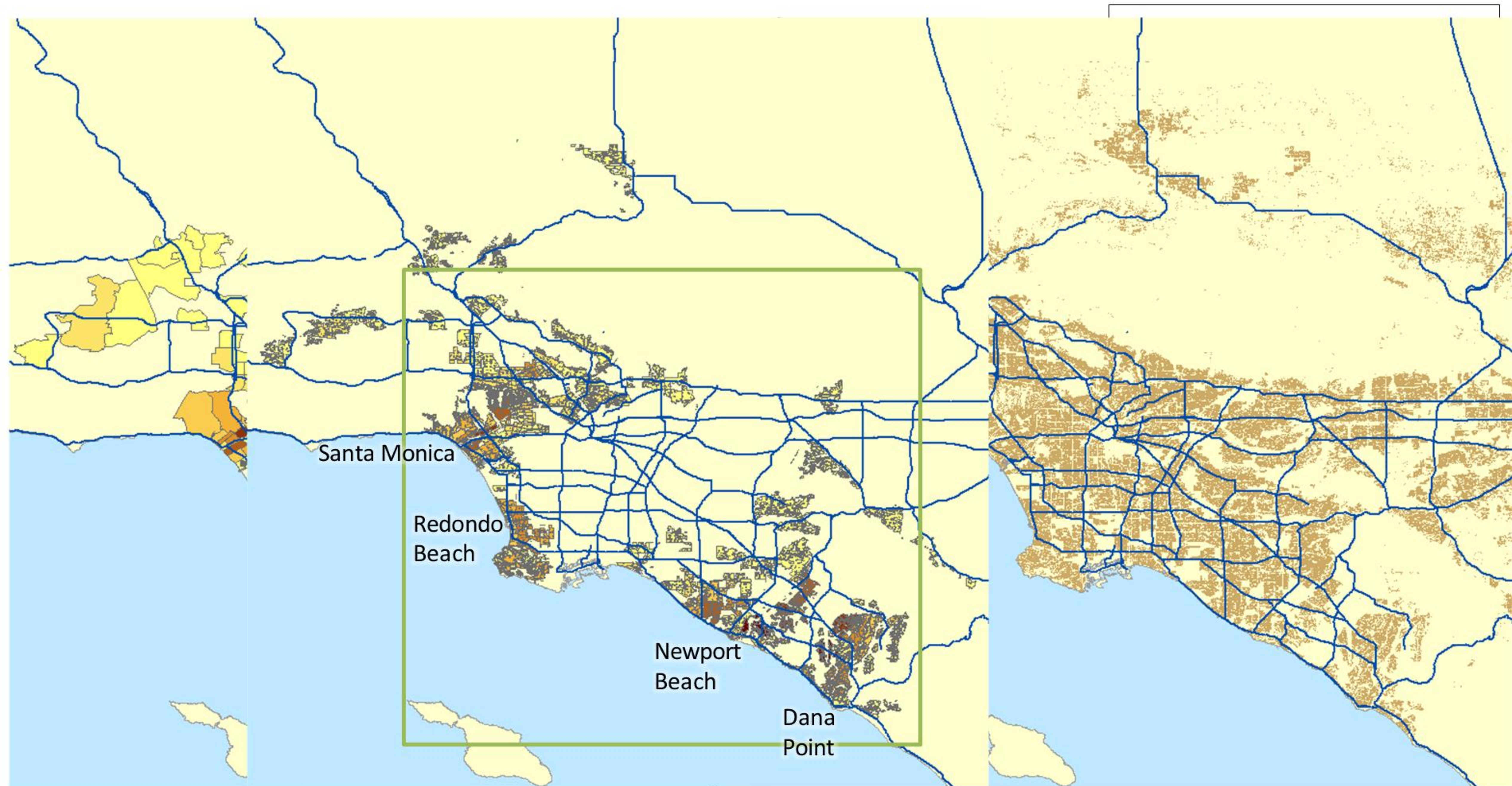
TO DETERMINE:

- Infrastructure Rollout
- GHG Emissions
- Criteria Pollutant Emissions
- Energy Impacts
- Water Impacts
- Air Quality Impacts

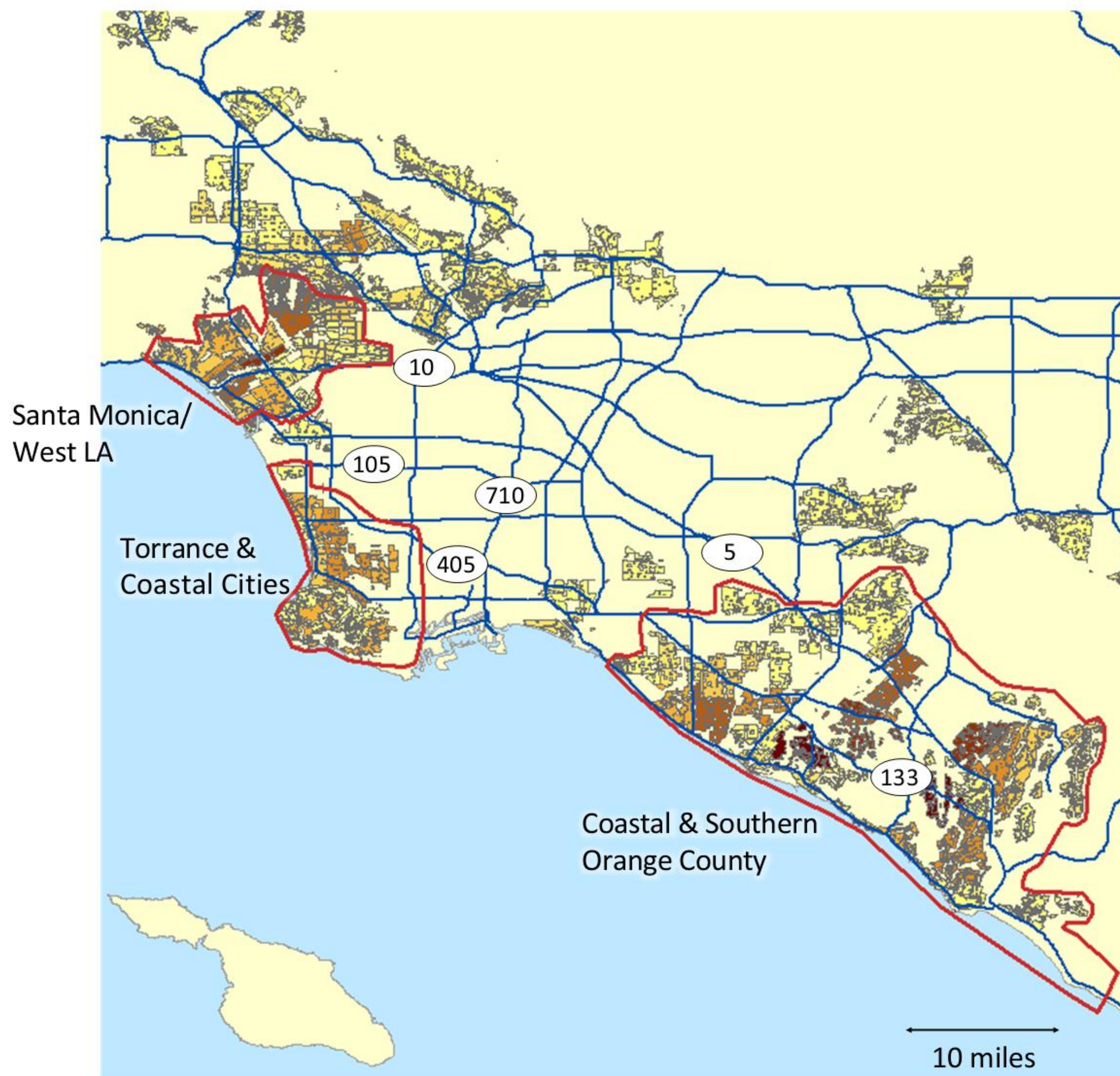
Building a Hydrogen Station Network



Determining Cluster Areas: Southern California



Determining Cluster Areas: Southern California



Interstates and freeways

FCEV target regions

FCEV Interest based on OEM customer data

Higher interest



Lower interest



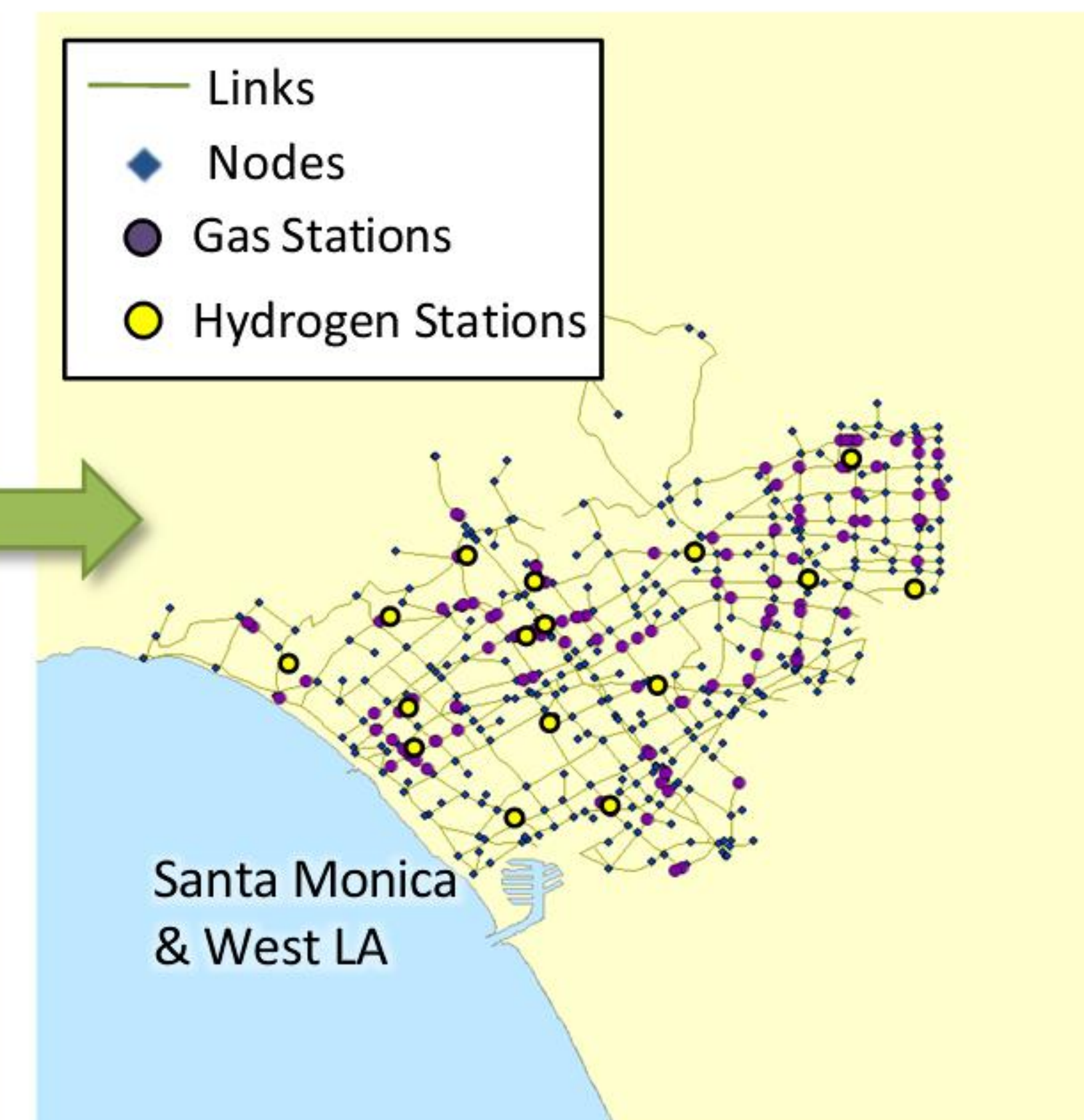
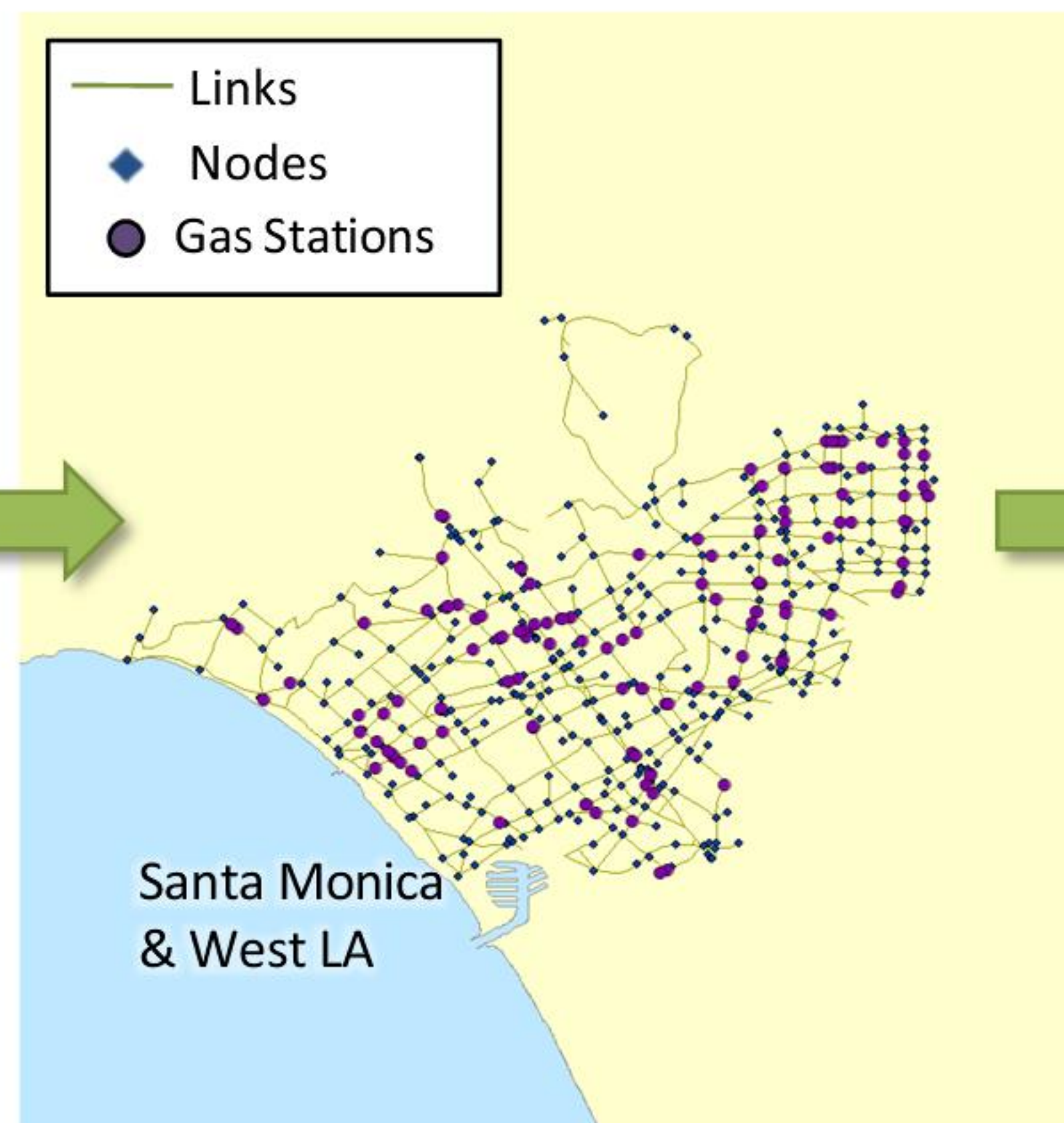
Robust Network in Cluster Areas

Target regions for FCEV early commercial market	Clusters within target region
South Coast Air Basin	Santa Monica and West Los Angeles
	Coastal and southern Orange County
	Torrance and nearby coastal cities
San Francisco Bay Area	South SF Bay Area
	Berkeley Area



Station Location Optimization

EXAMPLE: Santa Monica & West LA



- Determine a cluster area based on best projected early markets for fuel cell electric vehicles.

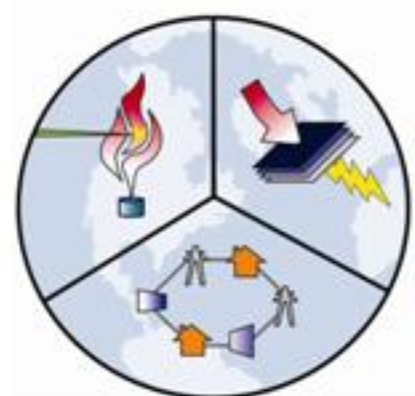
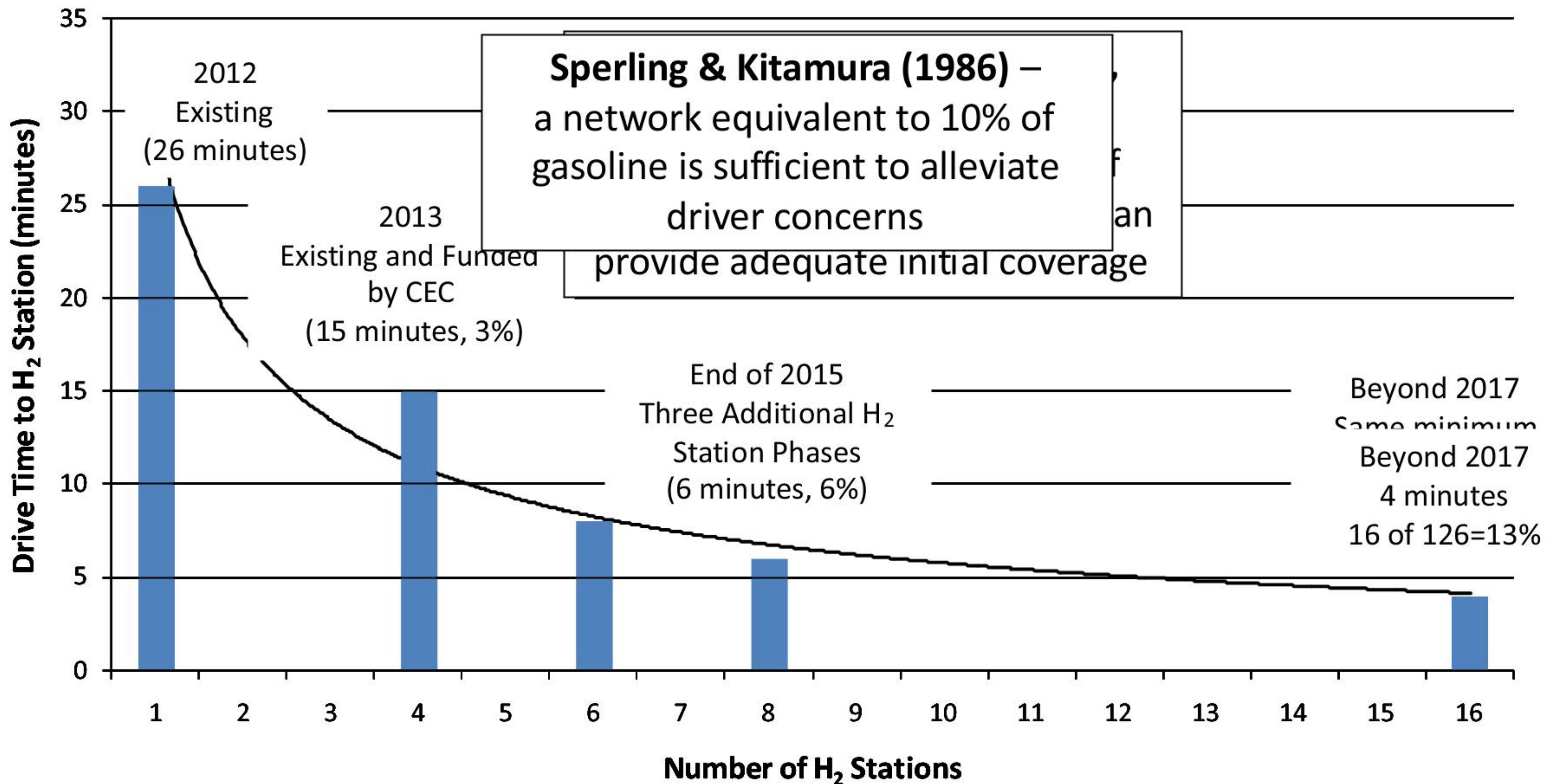
- Create a domain for modeling driving on freeways and major roads.
- Determine accessibility to existing gasoline stations (number of gas stations = 126).
- A gas station can be reached within 4 minutes or less.

- Apply an optimization routine to determine the number and location of hydrogen stations needed to provide varying degrees of accessibility.
- 16 strategically located hydrogen stations provide accessibility in 4 minutes or less.



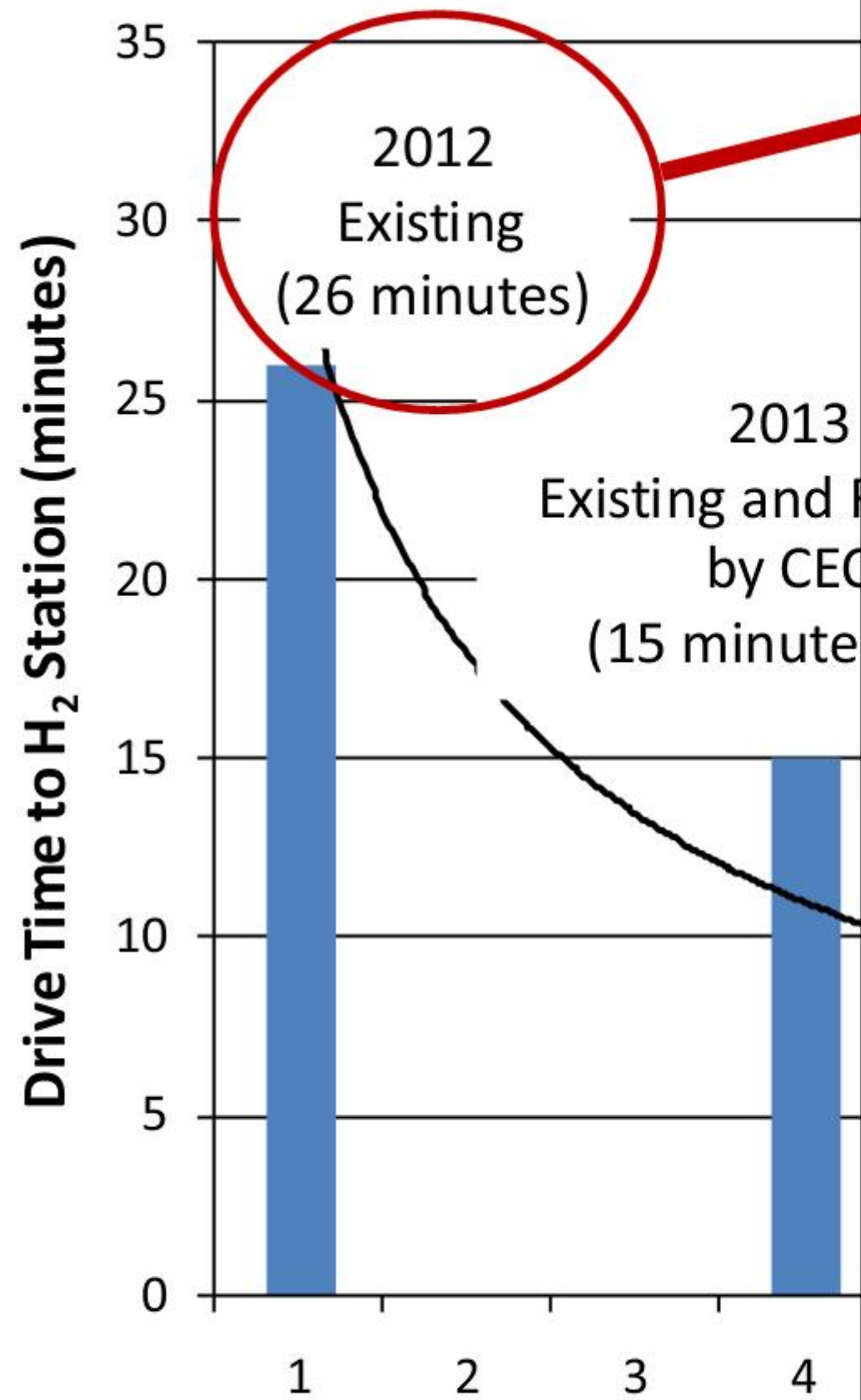
Station Location Optimization

EXAMPLE: Santa Monica & West LA



Station Location Op

EXAMPLE: Santa Monica

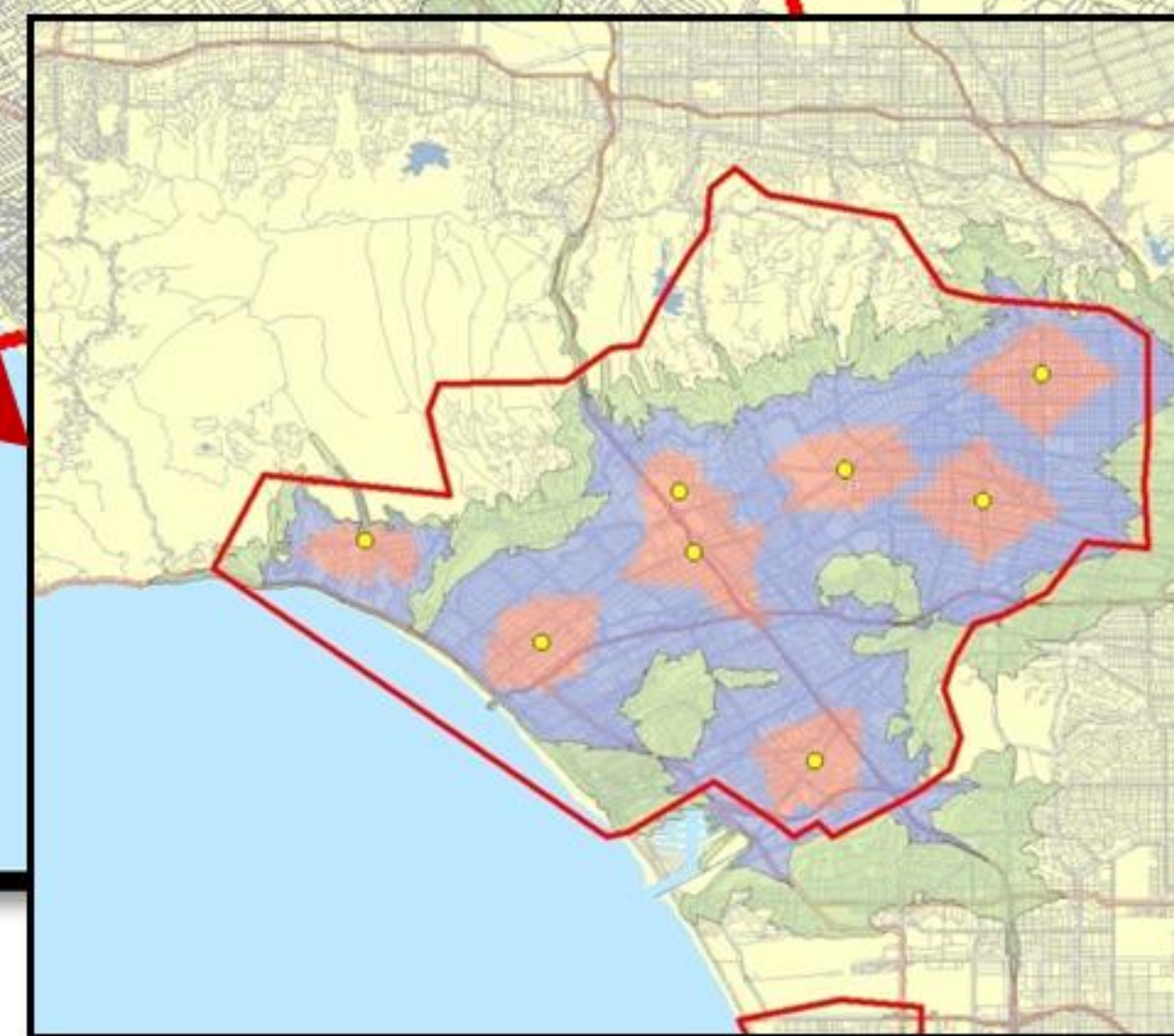
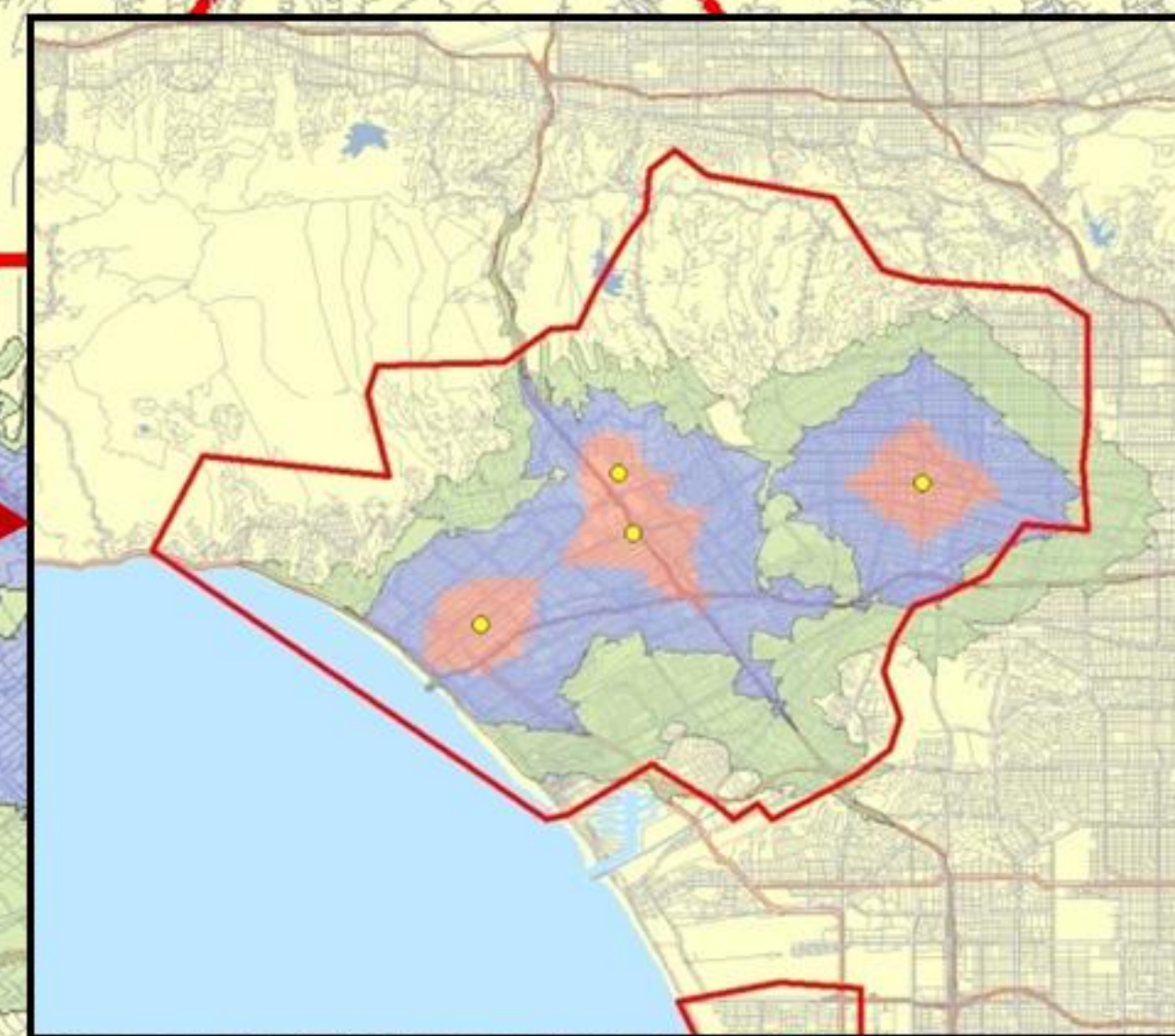
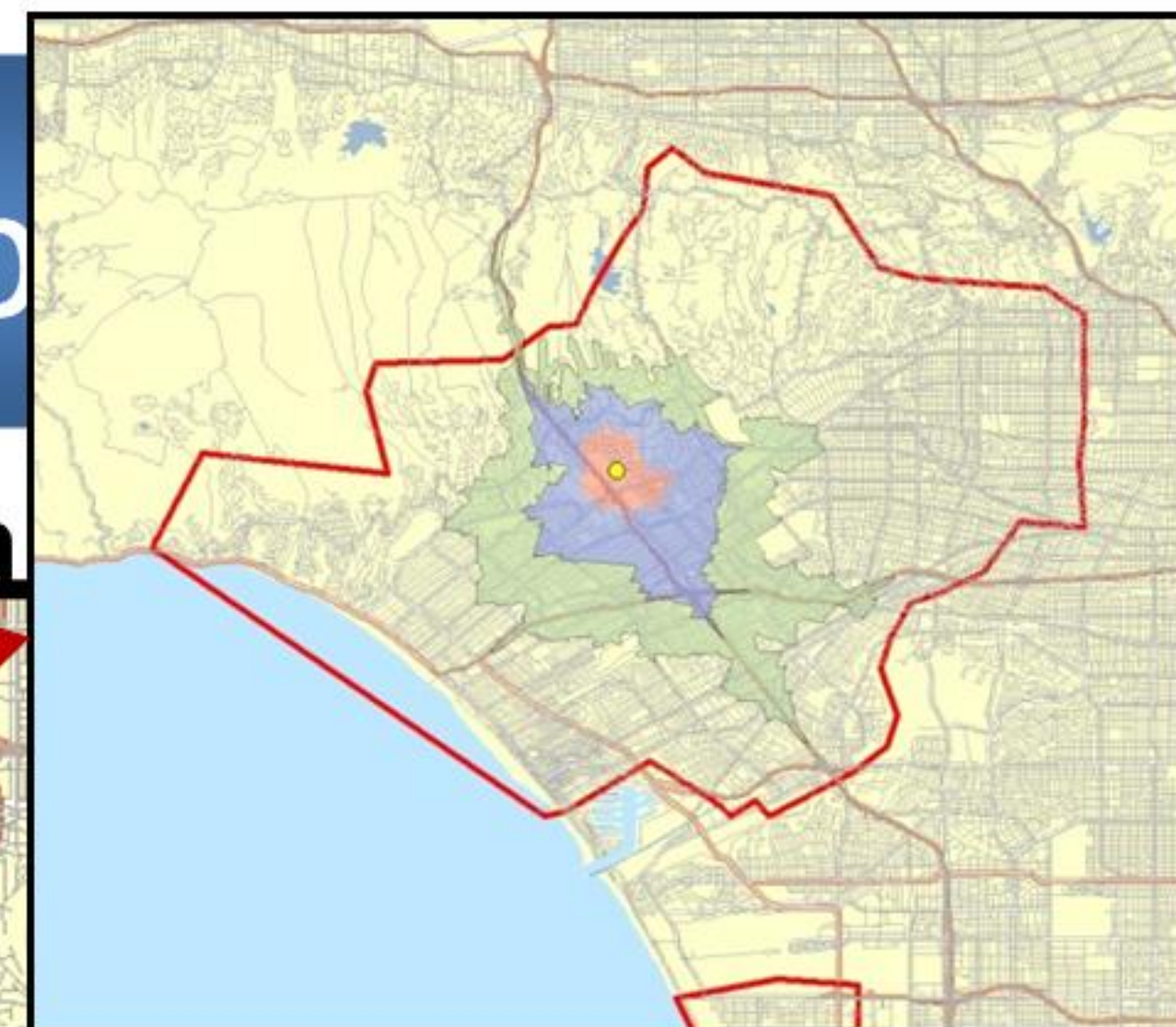


2012
Existing
(26 minutes)

2013
Existing and by CEO
(15 minutes)

Driving Time:

- 2 min
- 4 min
- 6 min



2017
minutes
6=13%

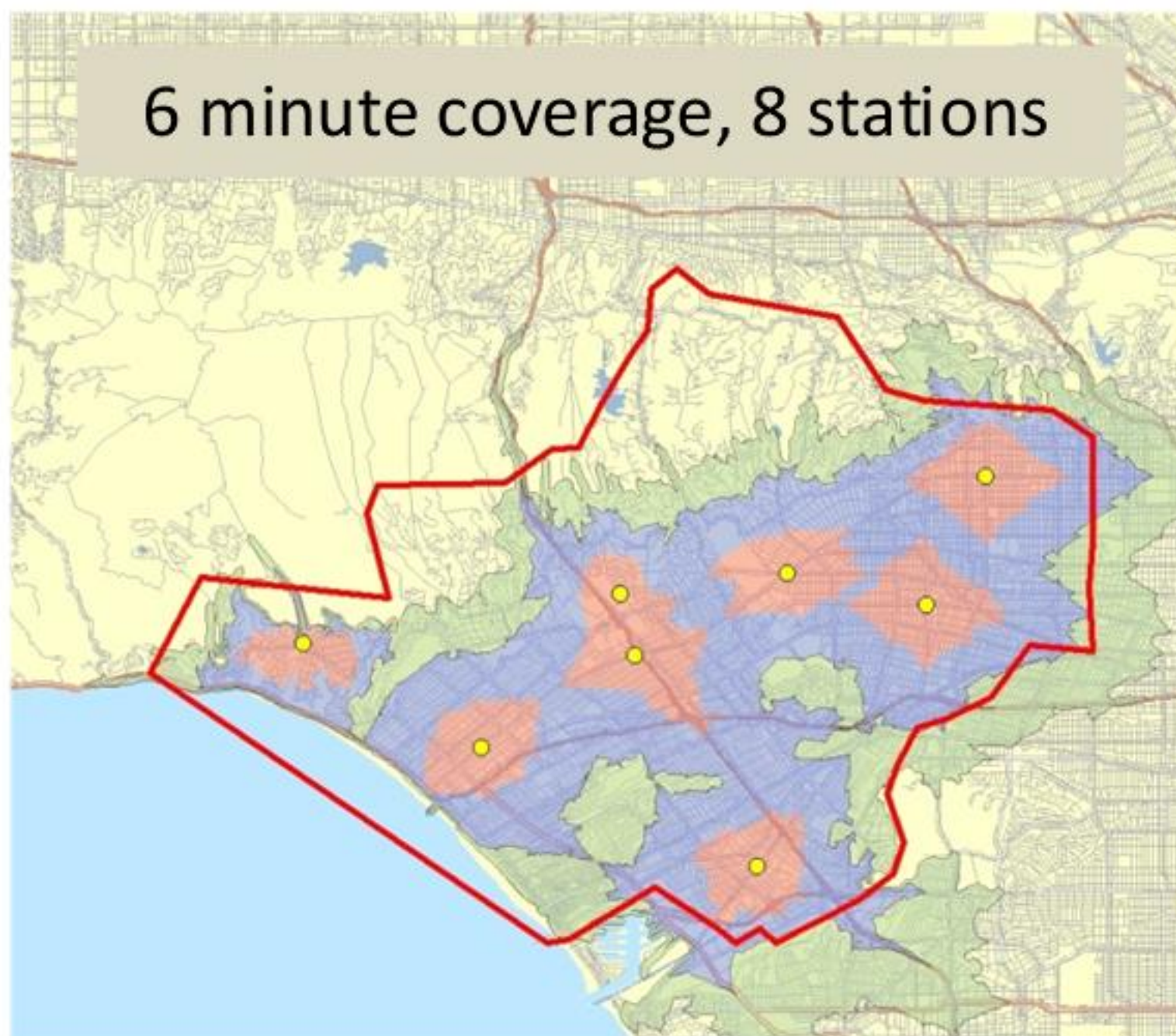
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12/23

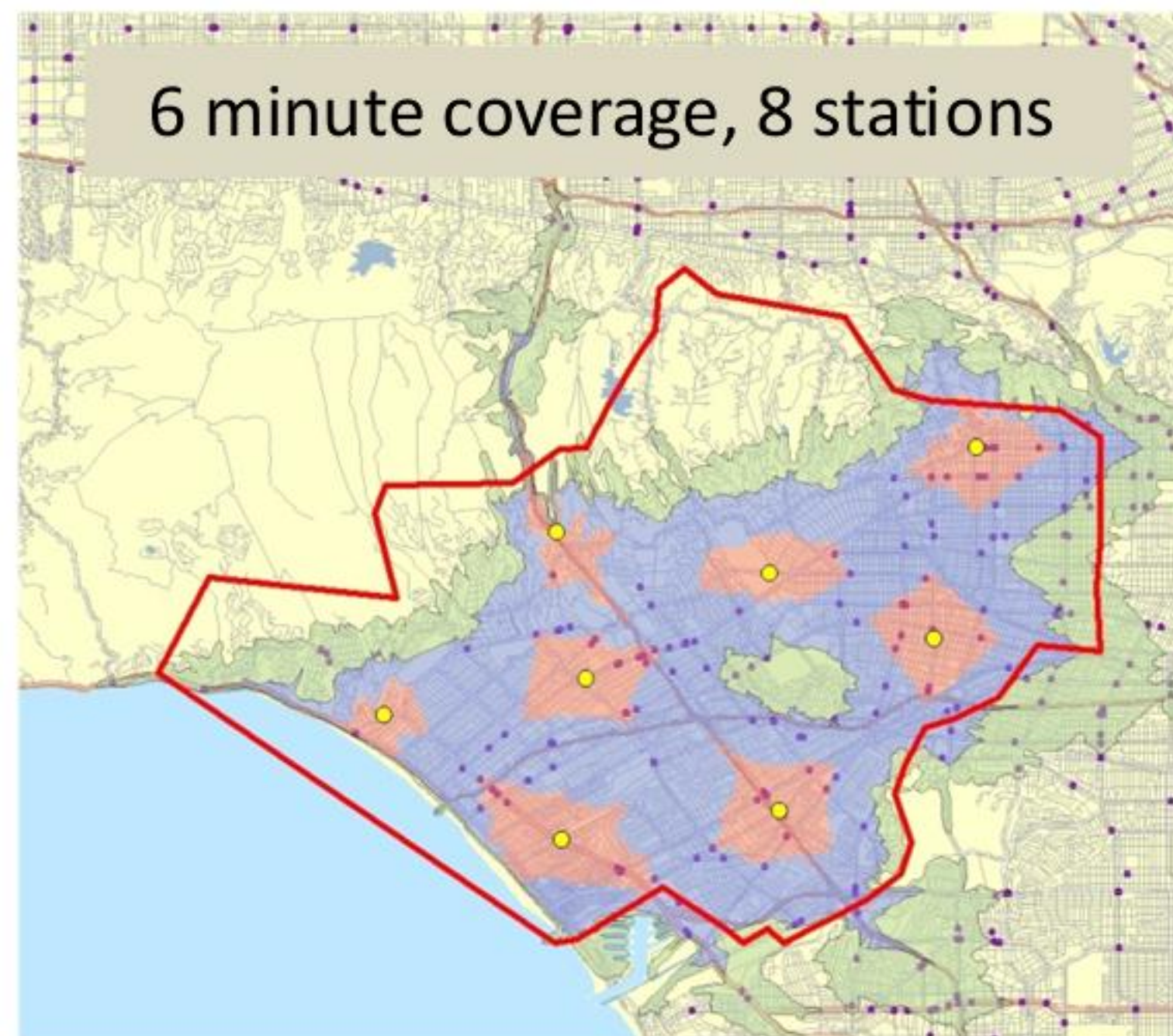


Robust Methodology

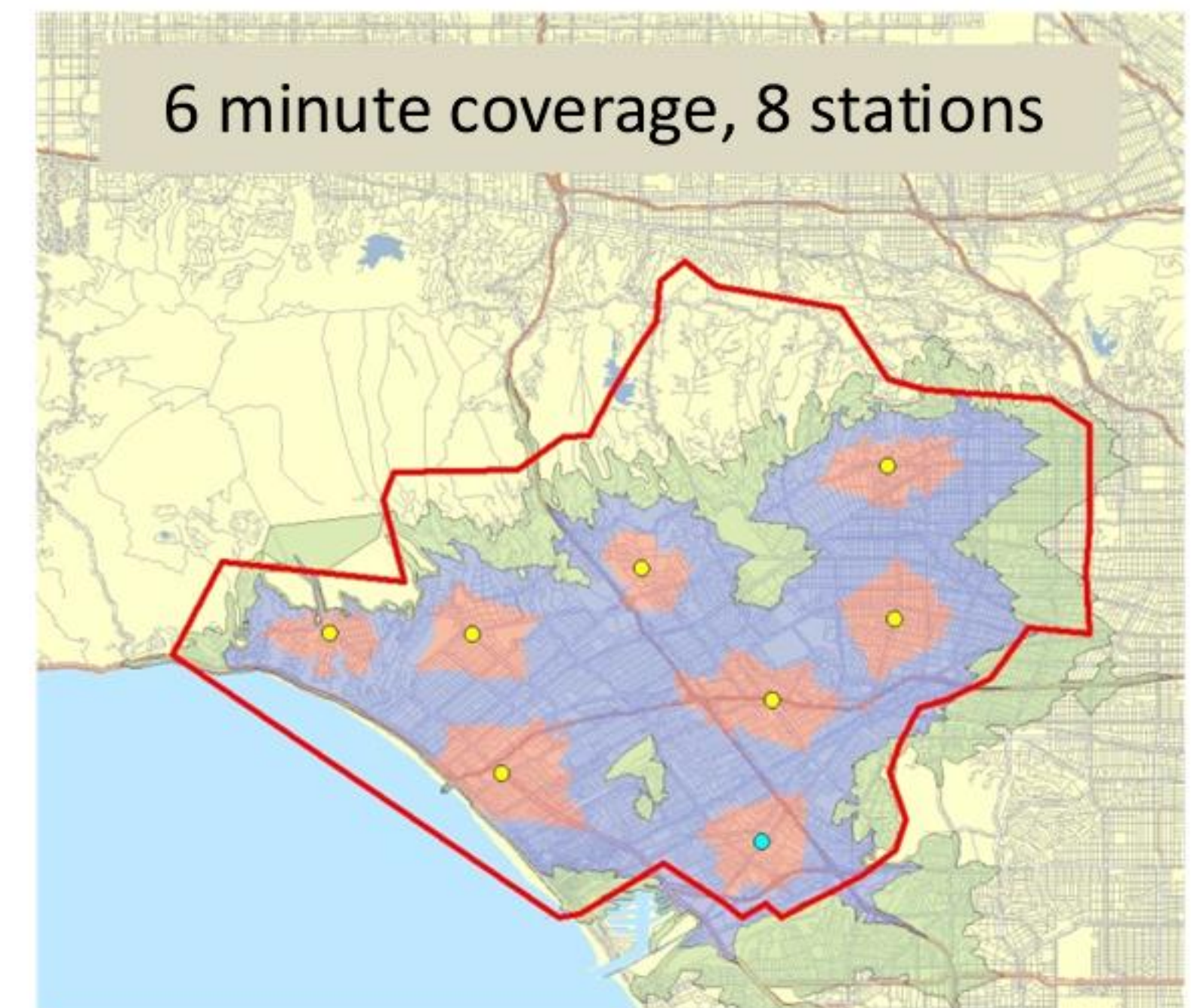
- Robust methodology determines multiple solution sets
- Allows for consideration of complex realities of infrastructure siting
 - Contracting
 - Permitting
 - Land owners
 - Station branding
 - Consumer interest



Santa Monica Configuration # 1



Santa Monica Configuration # 2



Santa Monica Configuration # 3

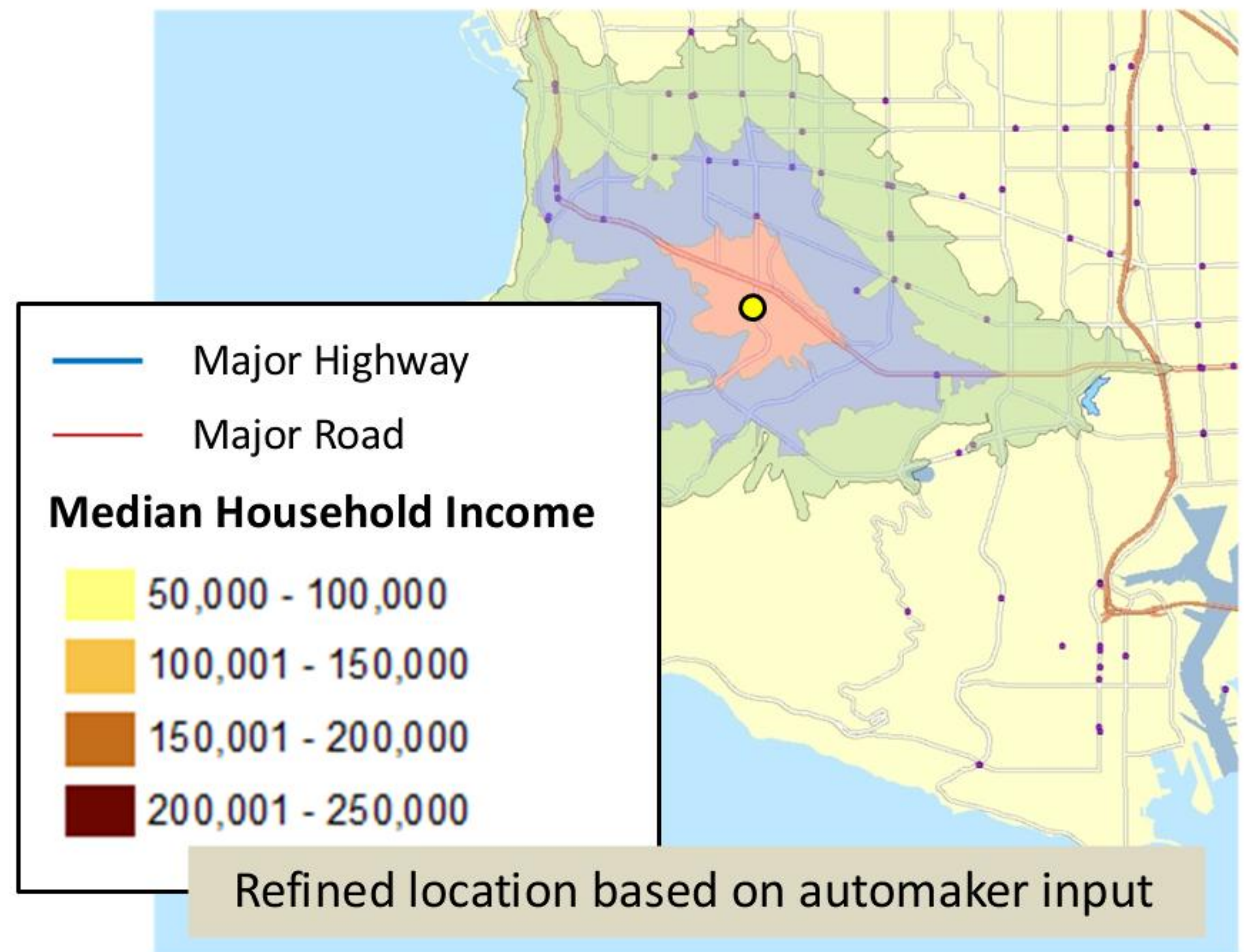


Robust Methodology

- Model optimization algorithm is just one component to best station site selection
- Other criteria such as ***OEM vehicle deployment plans, land use, vehicle travel density, service coverage, cost, and station performance*** can prioritize one location compared to another



Palos Verdes Peninsula



Palos Verdes Peninsula



Building a Cohesive Network

GOAL: California is prepared for deployment of fuel cell electric in a commercial scale

Geographic focus	Existing & planned	Additional	Total
Santa Monica/West LA	3	5	8
Torrance & Beach Cities	4	4	8
Southern & Costal OC	4	9	13
Berkeley	1	3	4
South SF Bay	1	11	12

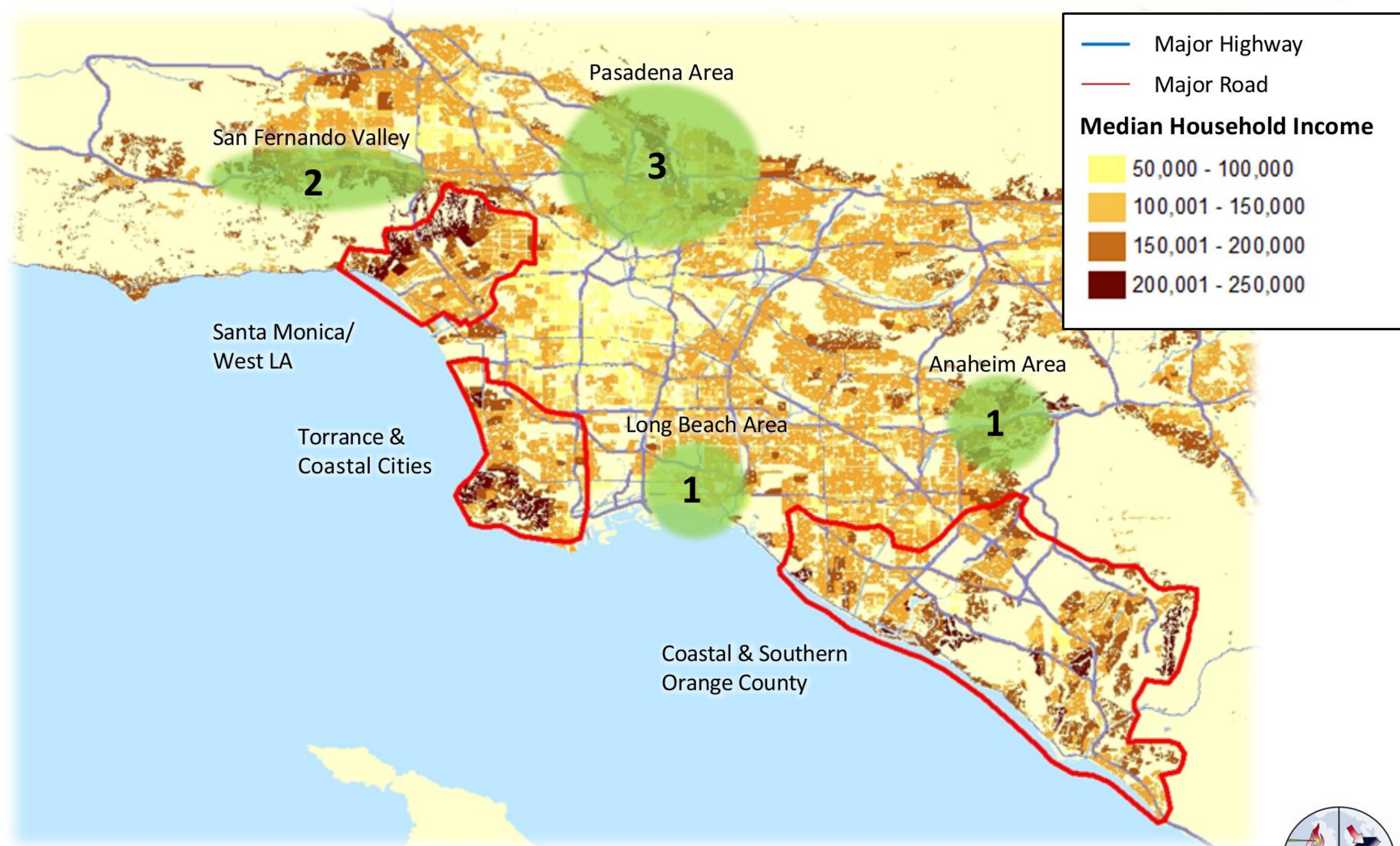
Establish a robust network of stations in cluster areas

Seed new clusters to solidify a regional network of stations

Provide connector and destination stations



Merge Clusters into a Regional Network (SoCal example)



Building a Cohesive Network

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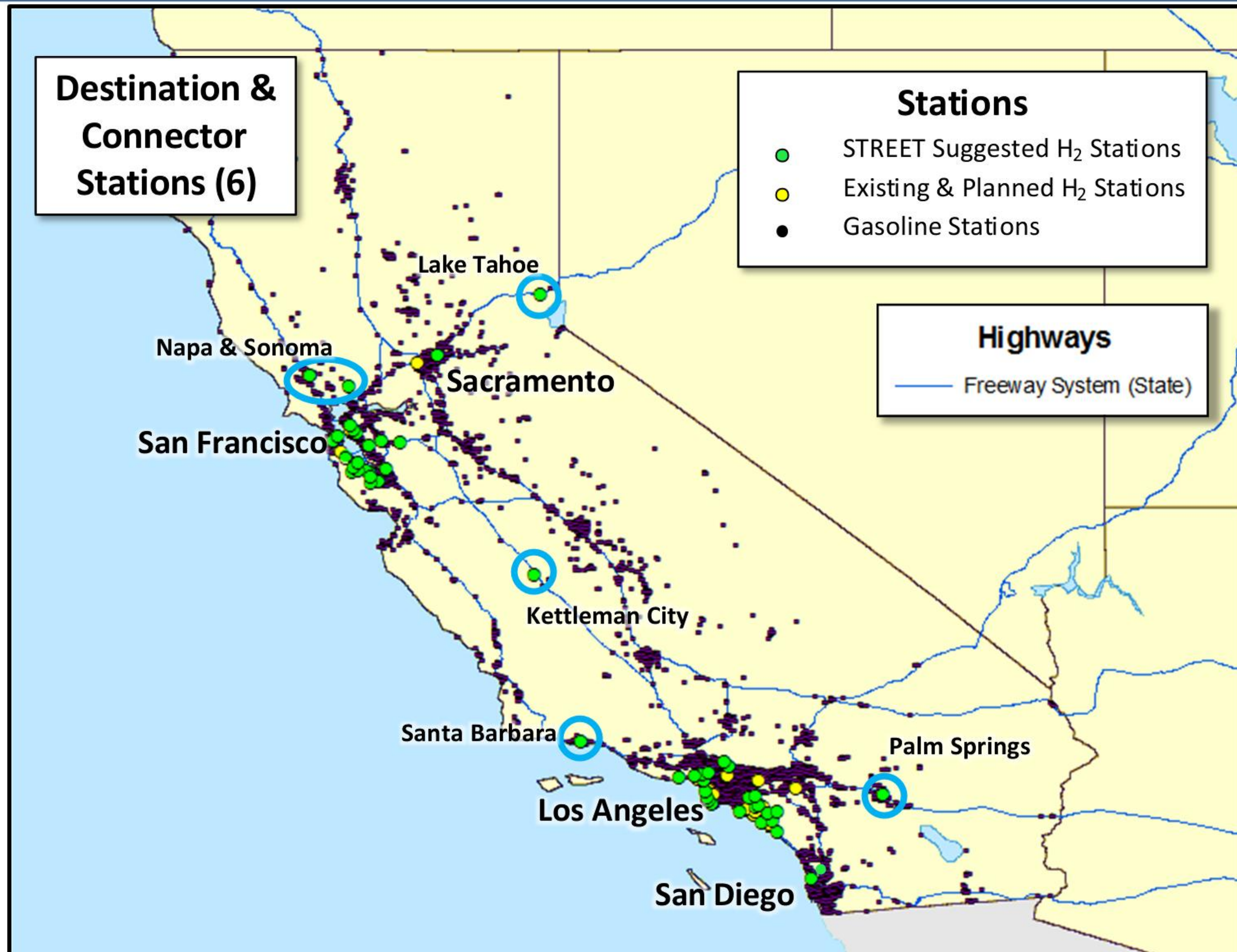
Establish a robust network of stations in cluster areas

Provide connector and destination stations

Geographic focus	Existing & planned	Additional	Total
San Fernando Valley	1	1	2
Pasadena Area	1	2	3
Sacramento	1	1	2
San Diego	0	2	2
Remainder of CA	1	7	8



Connector and Destination Stations



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Berkeley	1	3	4
South SF Bay	1	11	12

Focus area	Existing & planned	Additional	Total
Typical destinations	0	6	6

Establish a robust network of stations in cluster areas

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San Fernando Valley	1	1	2
Pasadena Area	1	2	3
Sacramento	1	1	2
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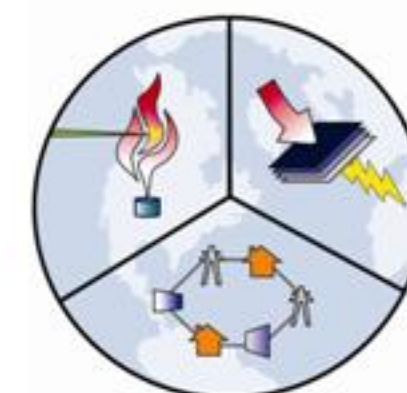
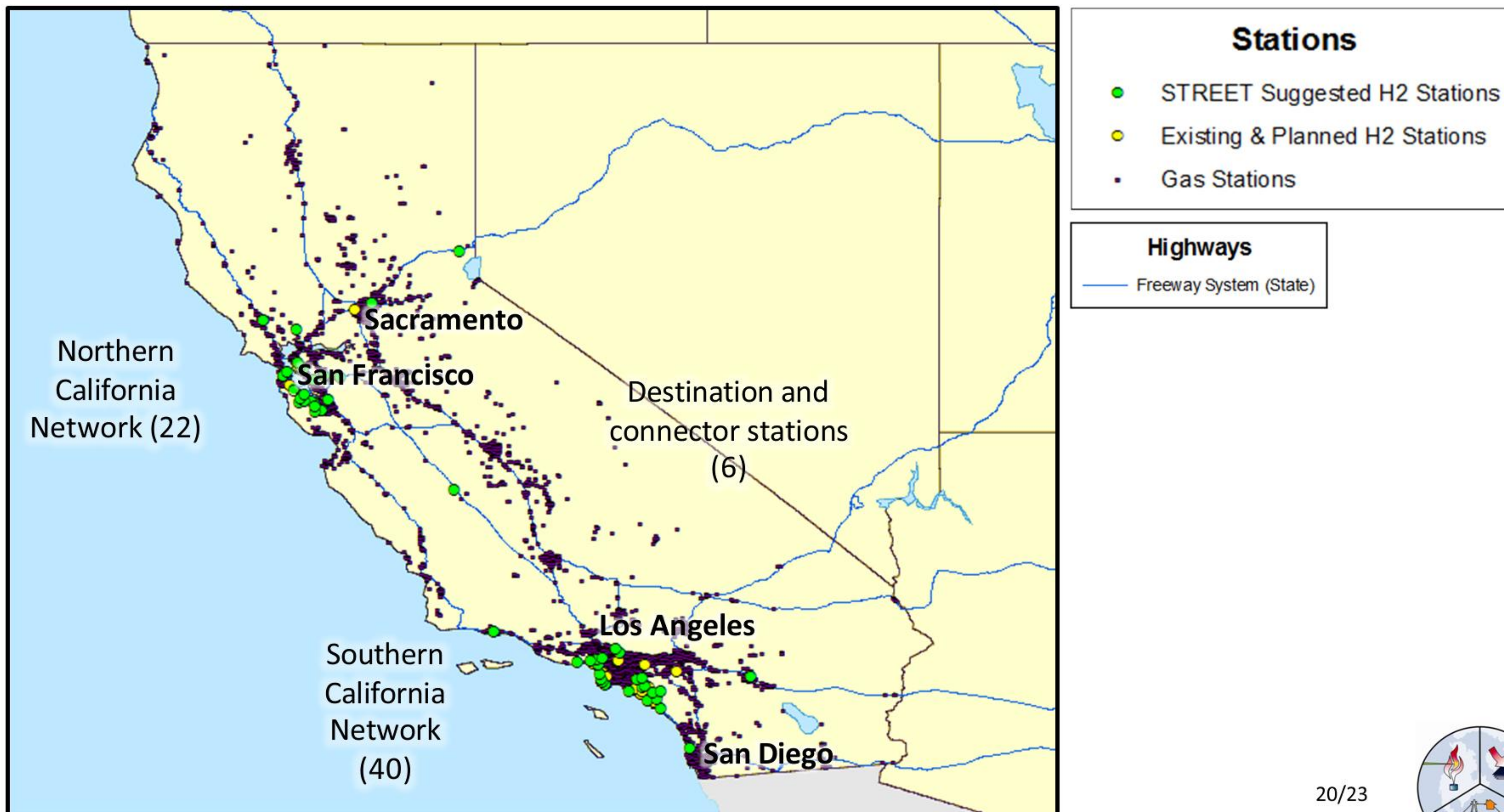
Provide connector and destination stations



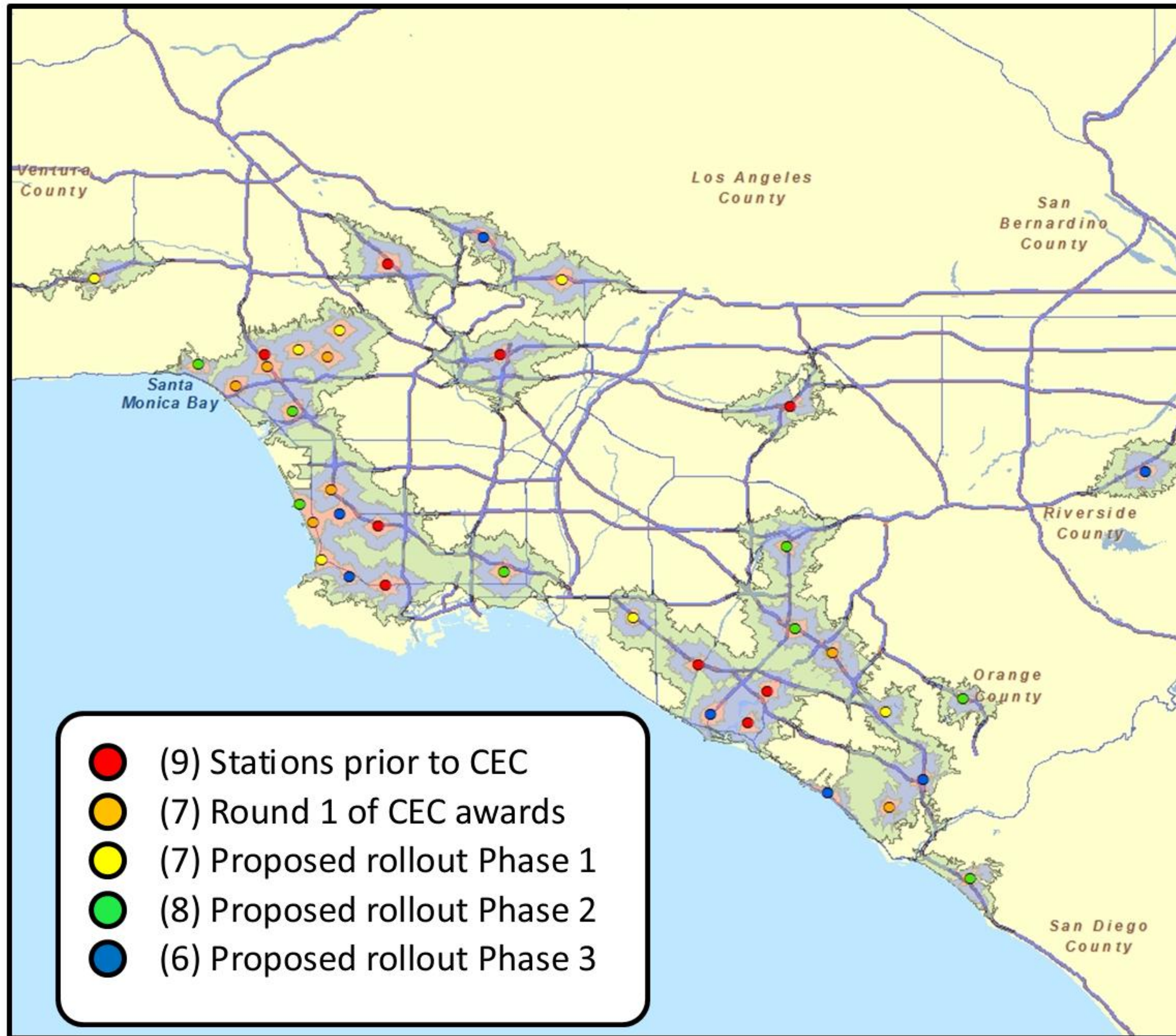
Strategic Plan for Roll-Out of H₂ Stations

Hydrogen fueling stations required by the start of 2016

68 total stations (17 existing & planned stations plus 51 additional stations) strategically located throughout California



H₂ Station Rollout (Southern California Example)



Population Covered in 6 min

- 2.7 million people (17%)
- 3.9 million people (25%)
- 4.7 million people (30%)
- 5.8 million people (37%)
- 6.1 million people (39%)

24 minutes

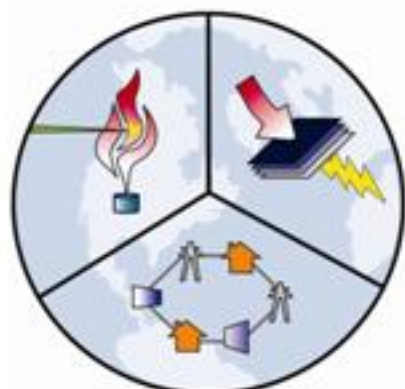
Drive time to H₂ station in target regions

15 minutes

9.4 minutes

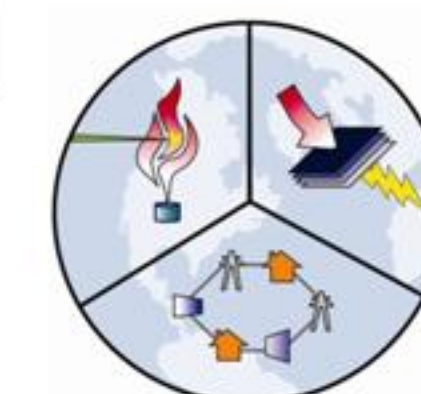
7.3 minutes

6 minutes



Strategic Network Plan

Location	Existing + ARB	CEC Funding Round 1	Proposed (Phase 1)	Proposed (Phase 2)	Proposed (Phase 3)	Total
Santa Monica	1	3	2	2	0	8
Torrance	2	2	1	1	2	8
OC	3	2	2	3	3	13
SF Bay Area	1		3	1	7	12
Berkeley	1				3	4
Anaheim area				1		1
Diamond Bar	1					1
Pasadena area	1		1		1	3
Long Beach				1		1
Riverside					1	1
San Fernando Valley	1		1			2
Hayward					1	1
Pleasanton					1	1
San Diego			1	1		2
Sacramento	1				1	2
SF (Downtown)			1	1		2
Lake Tahoe				1		1
Palm Springs				1		1
Santa Barbara				1		1
Napa					1	1
Sonoma					1	1
Kettleman City				1		1
	12	7	12	15	22	68



Key Contributing Partners

***We wish to acknowledge the following for their financial, informational,
and critical review contributions ...***

U.S. Department of Energy

California Energy Commission

California Air Resources Board

South Coast Air Quality Management District

San Joaquin Air Pollution Control District

California Fuel Cell Partnership

General Motors

Toyota

Honda

Hyundai/Kia

Mercedes-Benz

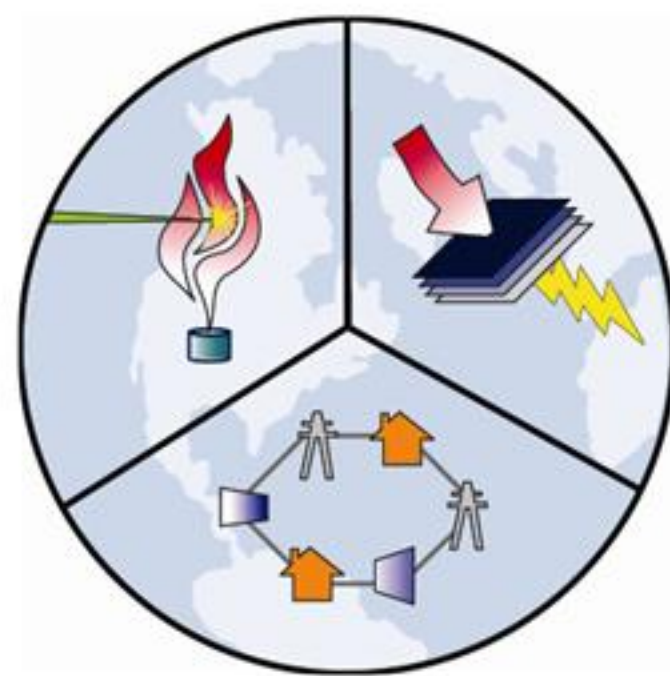
Nissan

Shell

Air Products

Linde

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ADVANCED POWER
& ENERGY PROGRAM
UNIVERSITY of CALIFORNIA • IRVINE

Dr. Tim Brown
Dr. Shane D. Stephens-Romero
James Soukup
Kersey Manliclic
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