CALIFORNIA HYDROGEN INFRASTRUCTURE TOOL (CHIT) 2017 RELEASE WEBINAR: UPDATES AND NEW CAPABILITIES

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For questions or comments, contact:
Andrew Martinez
(916) 322-8449
andrew.martinez@arb.ca.gov

CALIFORNIA
AIR RESOURCES BOARD

Discussion Outline

Purpose: To review updates made during 2015-2017 to the methodologies and data inputs provided with CHIT, the geographical information system tool developed by CARB to assist in analysis of needs for new hydrogen fueling infrastructure.

- Recap of CHIT fundamentals
- Simulated traffic intensity data
- Implementation of auto manufacturer survey and DMV registration data
- Alternative coverage gap formulation
- Coverage gap re-tuning tool
- Single station impact and re-evaluation tool
- Local capacity need calculation
- Evaluation grid geometry and coordinate system
- Demographic data updates and comparison to CVRP data
- Updated online map viewer
- Future implementation of CHIT

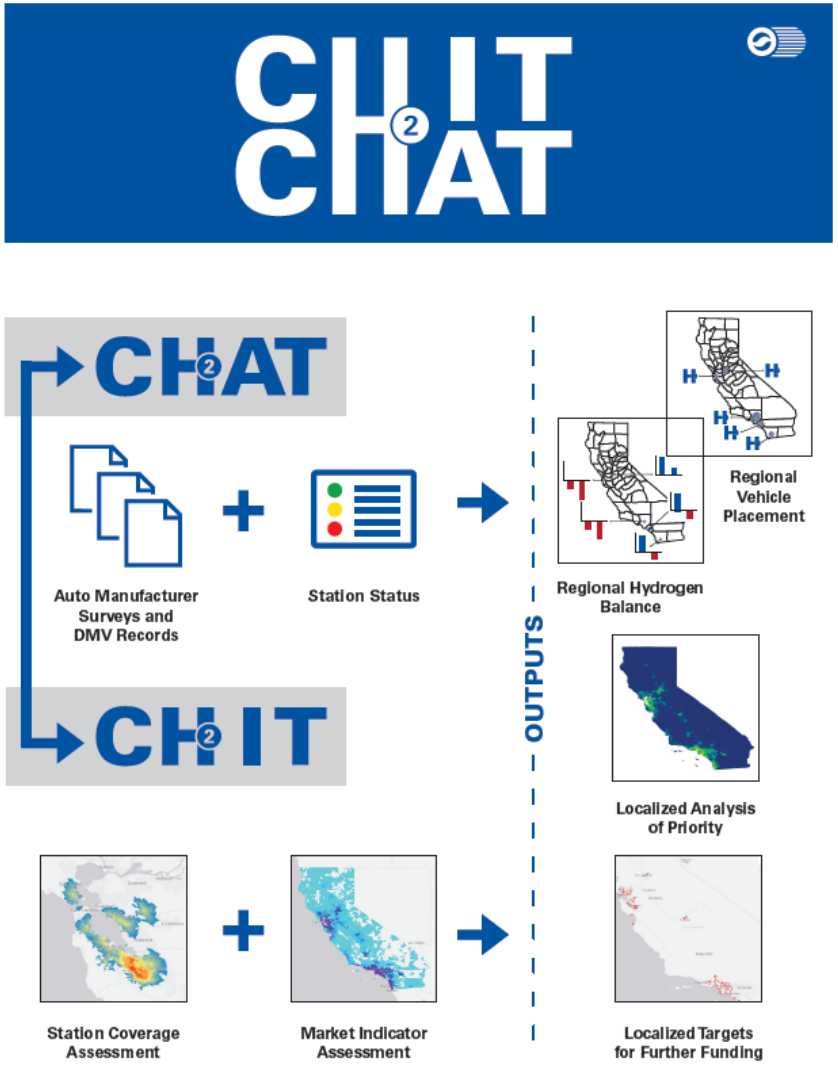
Discussion Outline

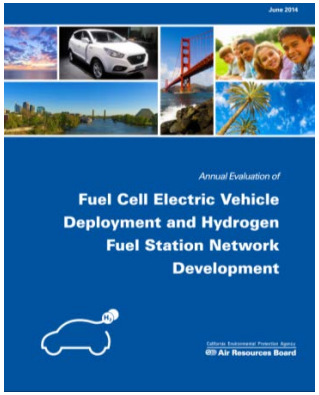
- This discussion will answer questions like:
  - What new features and data inputs are available with CHIT 2017 Release? How were they developed?
  - What defaults settings have been adjusted in CHIT 2017 Release compared to 2015 Release?
  - What data inputs have been updated with CHIT 2017 Release?
  - What new operations are available with CHIT 2017 Release?
  - What is the current plan for ongoing CHIT development and use?

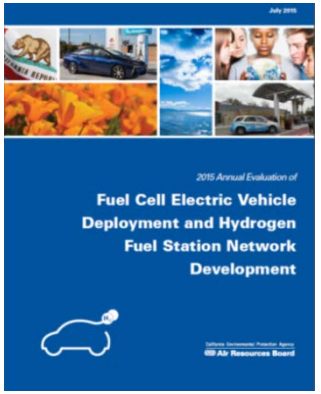
REVIEW OF CHIT 2015 RELEASE

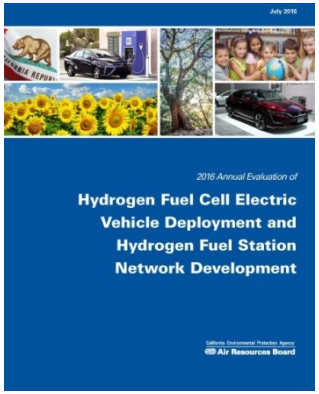
Review

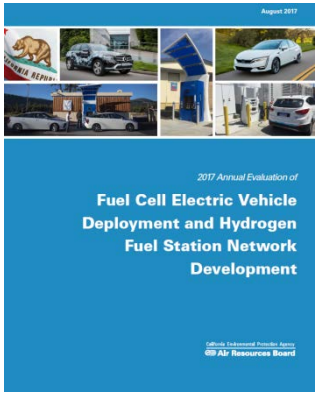
CHIT/CHAT Tools and AB 8

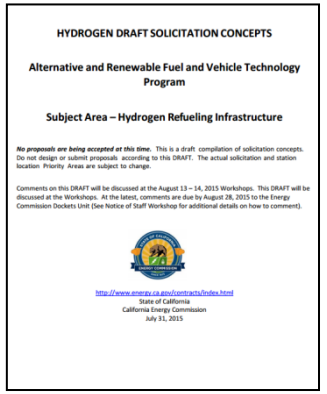












Review

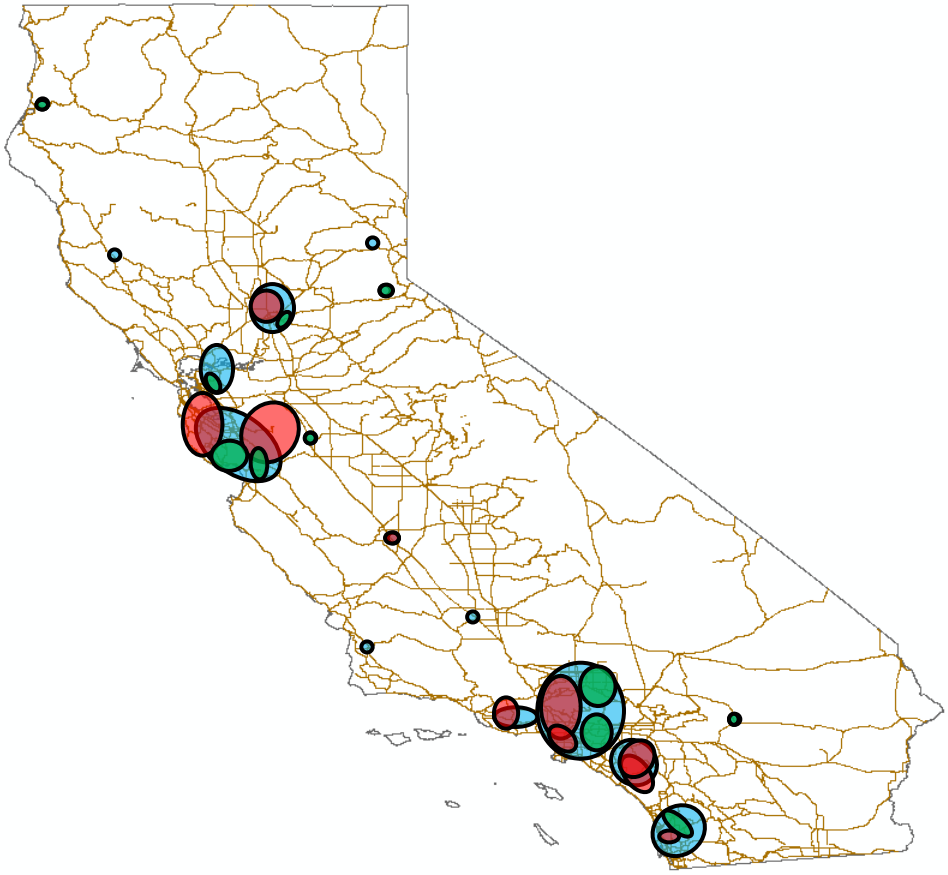
Big Picture Goal

Plan infrastructure placement appropriately for upcoming FCEV releases

1) Identify Market

2) Evaluate current infrastructure
   Existing and potential station coverage

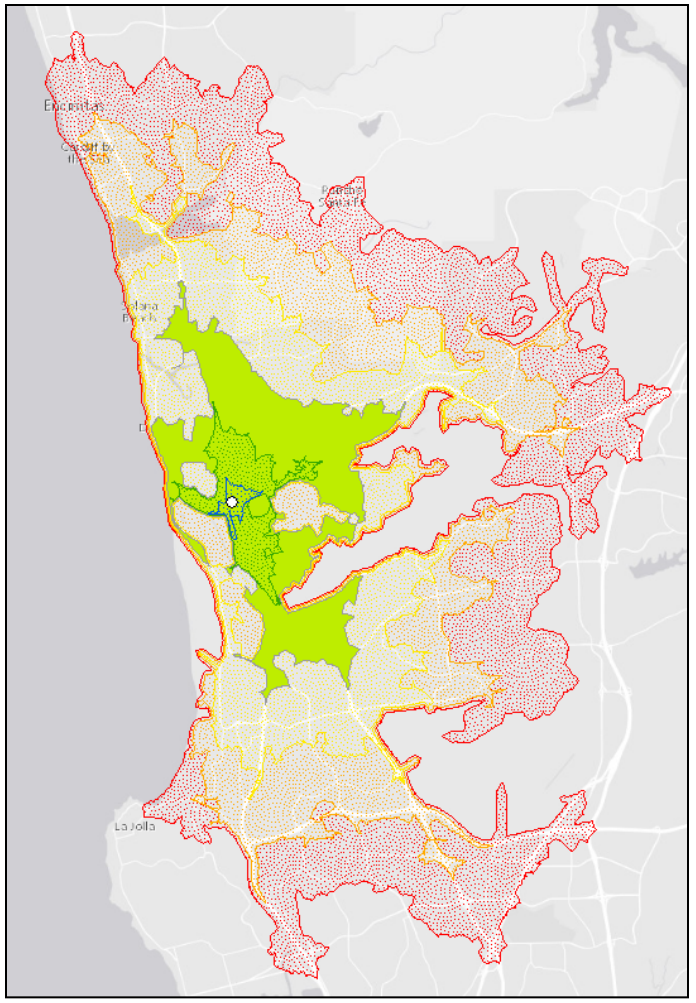
3) Prioritize uncovered market from year-to-year



Review

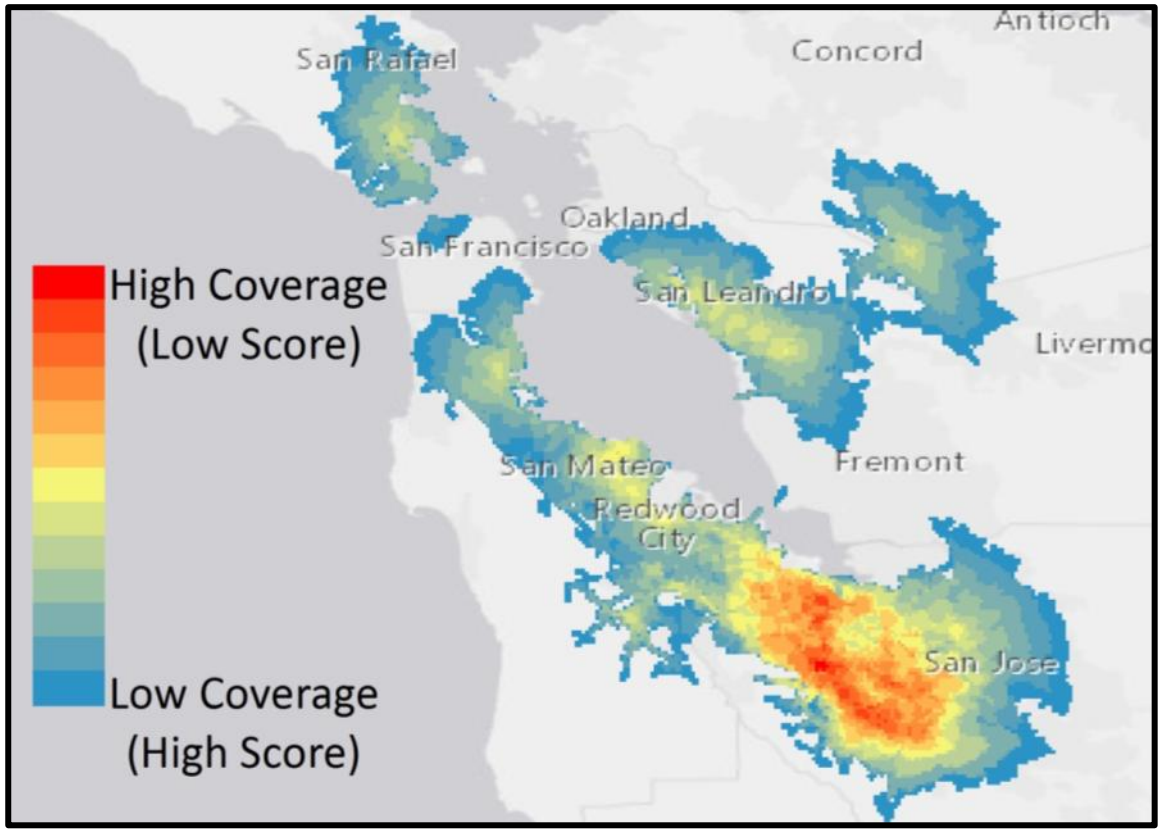
Central Theme: Coverage

- Conceptual representation of convenient access to fueling stations
- Often discussed in terms of drive time, e.g. coverage is provided to all neighborhoods within a 15-minute drive of a station
- Coverage can be conceptualized as binary (yes/no) or as degrees of coverage
- Well-planned coverage increases consumer confidence and adoption of vehicles



Review

Goals for Analyzing Existing Coverage

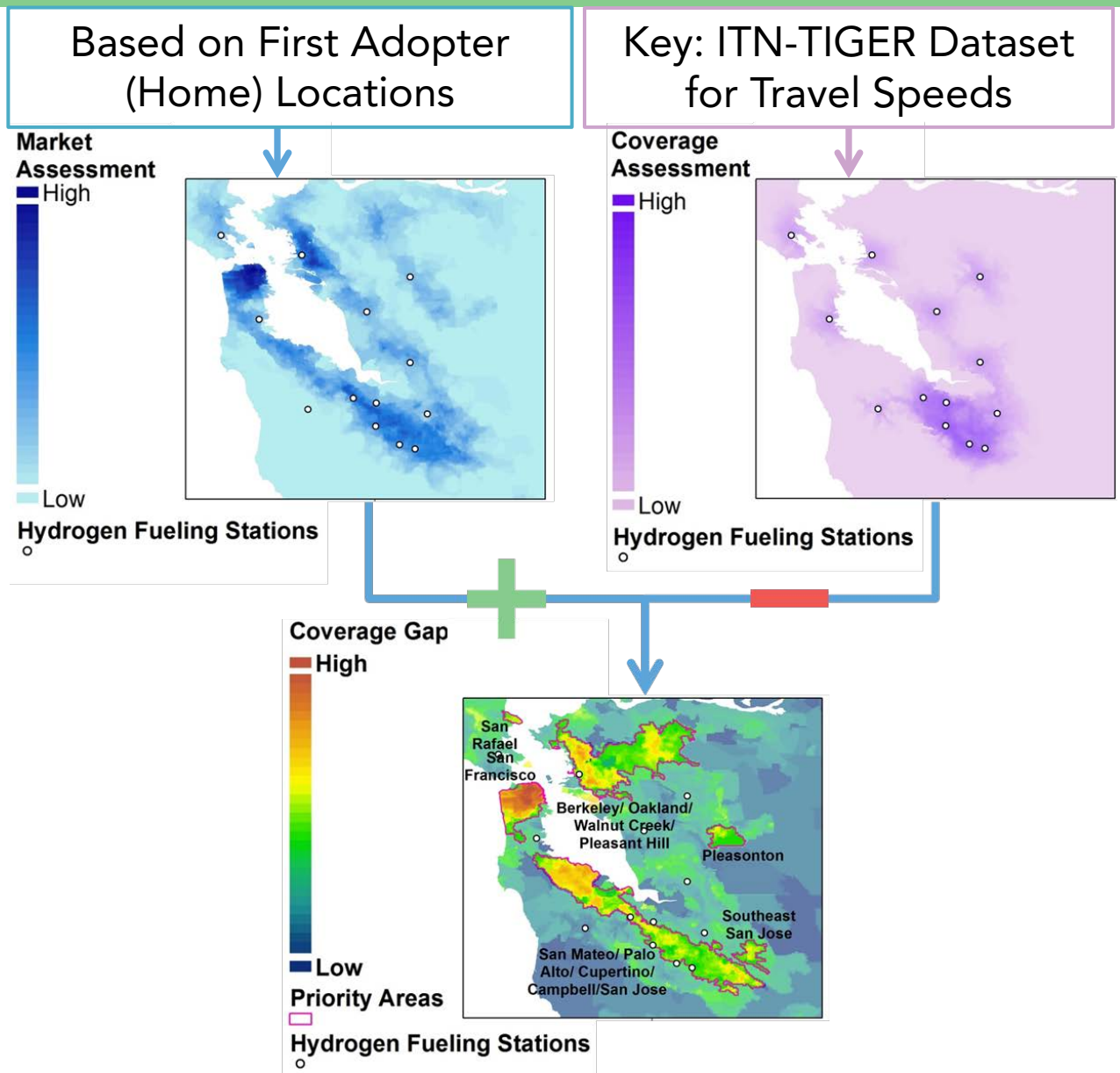


*Areas without coverage have no color and score highest

- Provides an estimate of coverage that is more informative than a binary yes/no, allowing for estimation of degrees of coverage
- Estimates combined coverage provided by multiple stations that may be reachable within various drive times

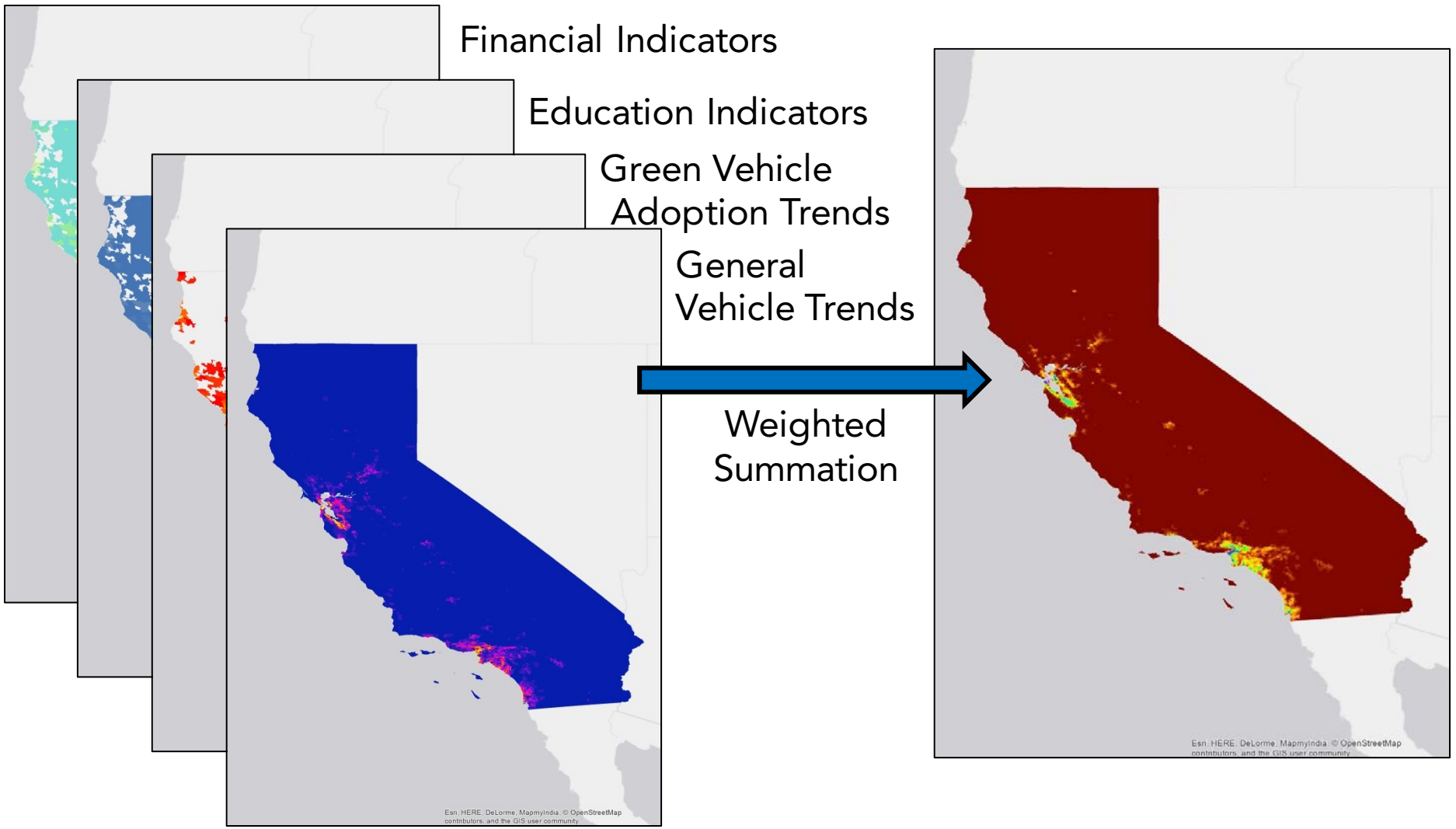
Review

- CHIT is a planning tool intended to provide general direction indicating areas of needed infrastructure
- CHIT evaluates relative need for hydrogen infrastructure based on a gap analysis between a projected market and current infrastructure



Review

Analyzing the Early Adopter Market



Review

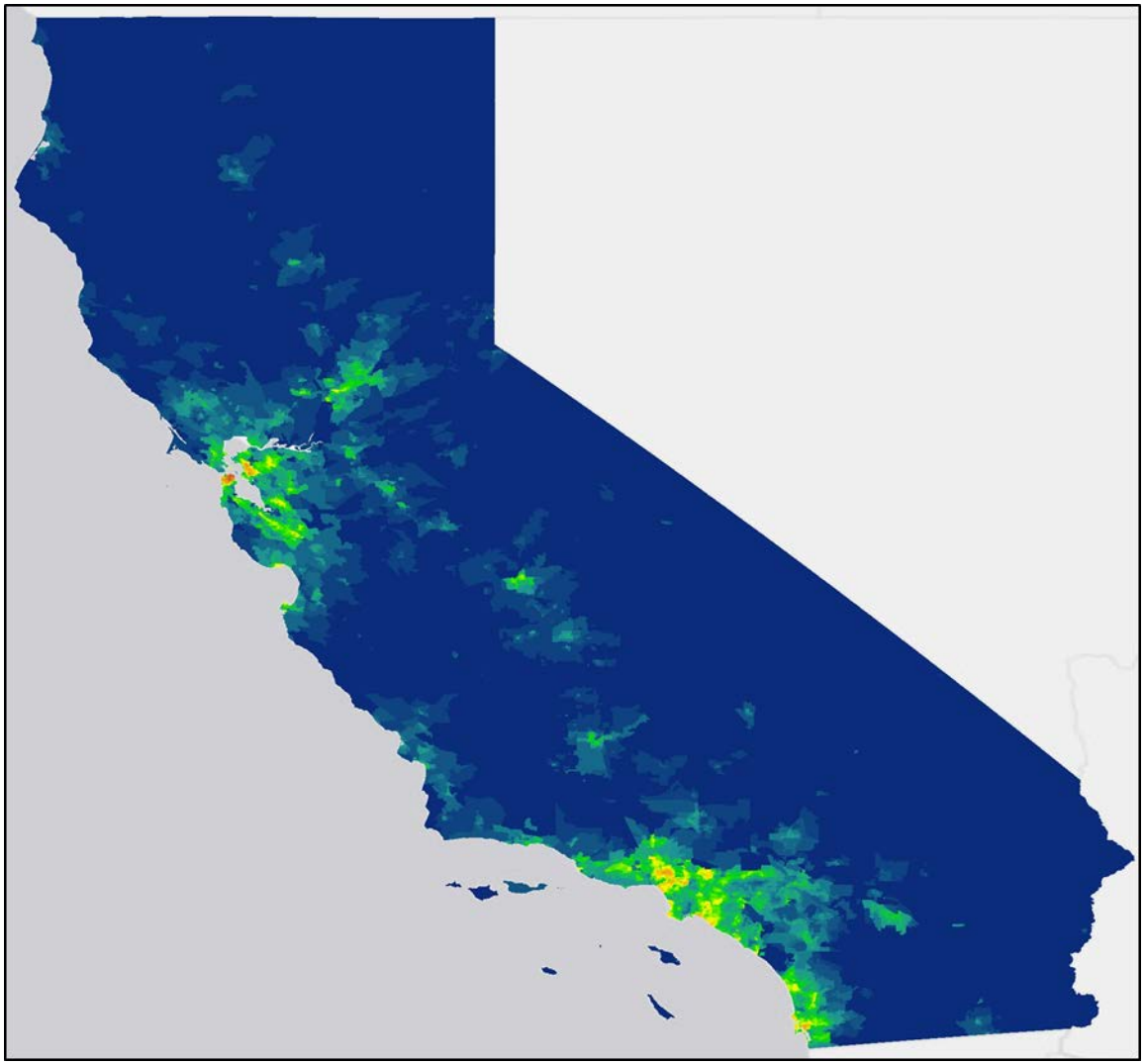
Coverage Gap Map Formulation

Heat = Coverage *
Market

Coverage= 0.5 * Existing +
0.5 * Potential

Market= 0.5 * Financial +
0.3 * P/HEV +
0.2 * Edu

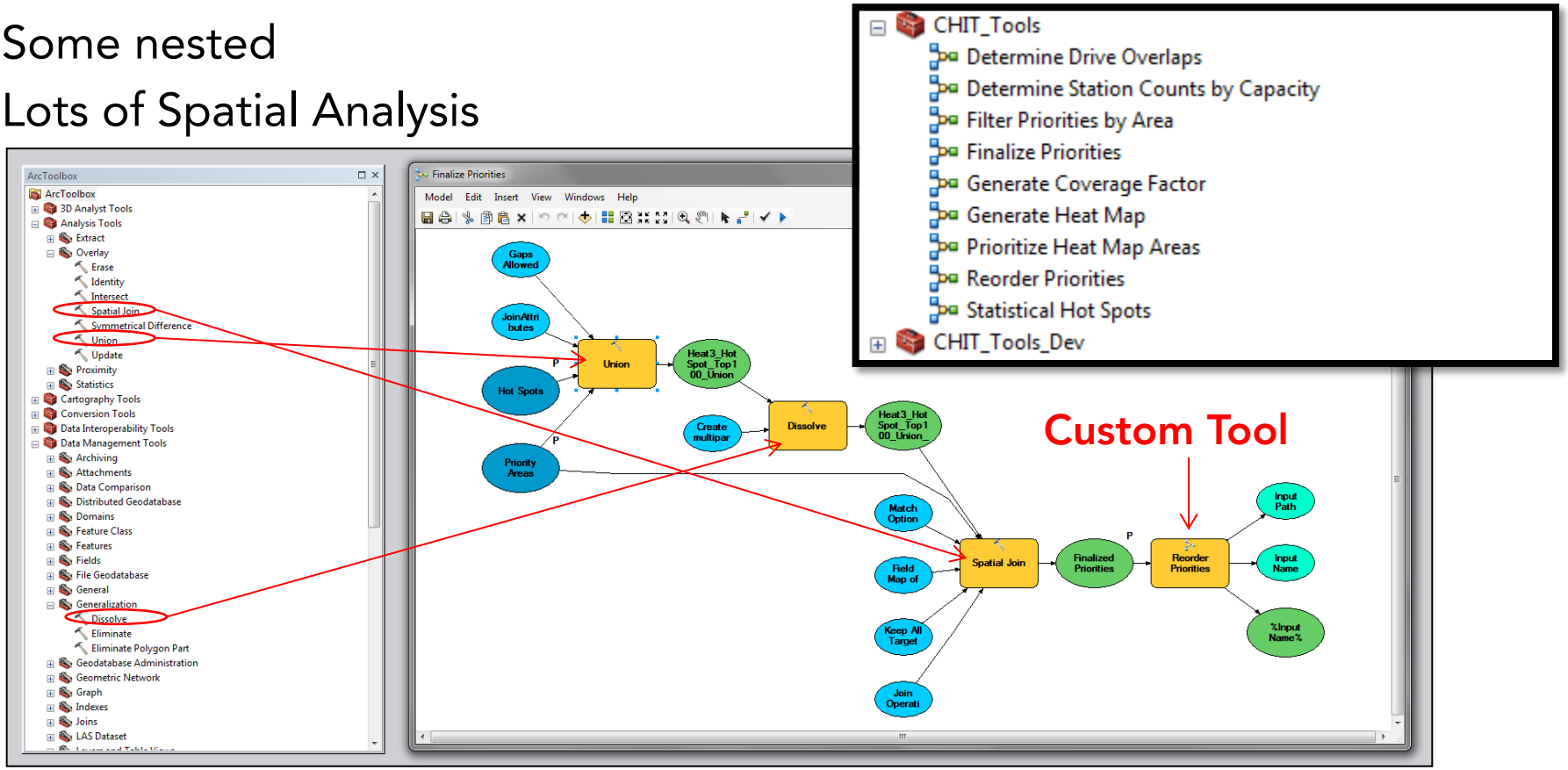
Financial= 0.34 * Income +
0.33 * MSRP +
0.33 * Luxury



Review

CHIT 2015 Toolbox

- CHIT is (mostly) a set of custom tools built in ArcGIS ModelBuilder
- Some iterative
- Some nested
- Lots of Spatial Analysis



Guiding Principles

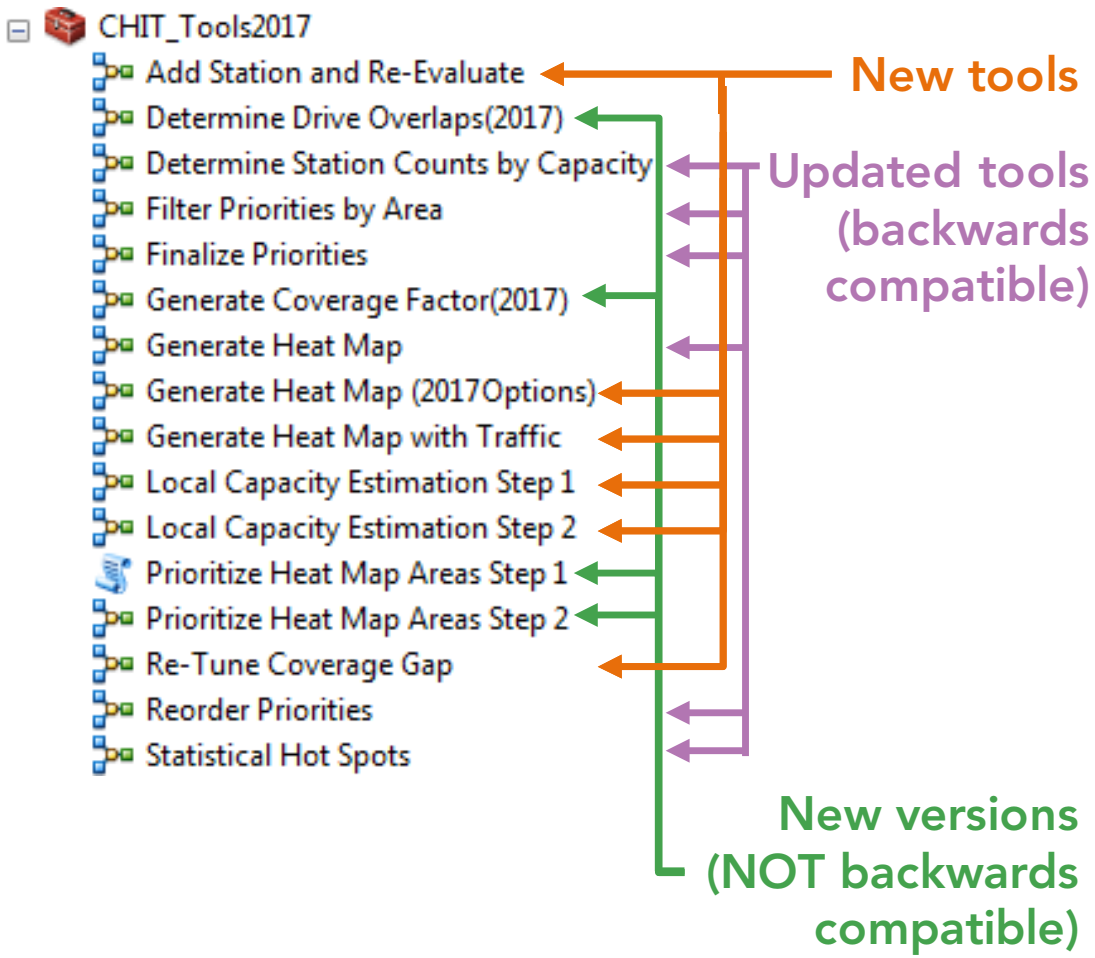
CHIT is envisioned as a tool that could be used year-after-year for public planning and reporting purposes, while providing a consistent assessment method across the entire state. Related fundamental principles guide development of CHIT:

- Principle #1: CHIT is a relative assessment
- Principle #2: CHIT is a statewide assessment
- Principle #3: CHIT assesses only the first adopter market
- Principle #4: The FCEV market can be estimated by the relative distribution of multiple demographic indicators
- Principle #5: Accurate assessment of coverage depends on detailed roadway data
- Principle #6: Coverage matches the market when it provides convenient fueling access near FCEV drivers' homes
- Principle #7: CHIT must be a tool that can be shared with the public

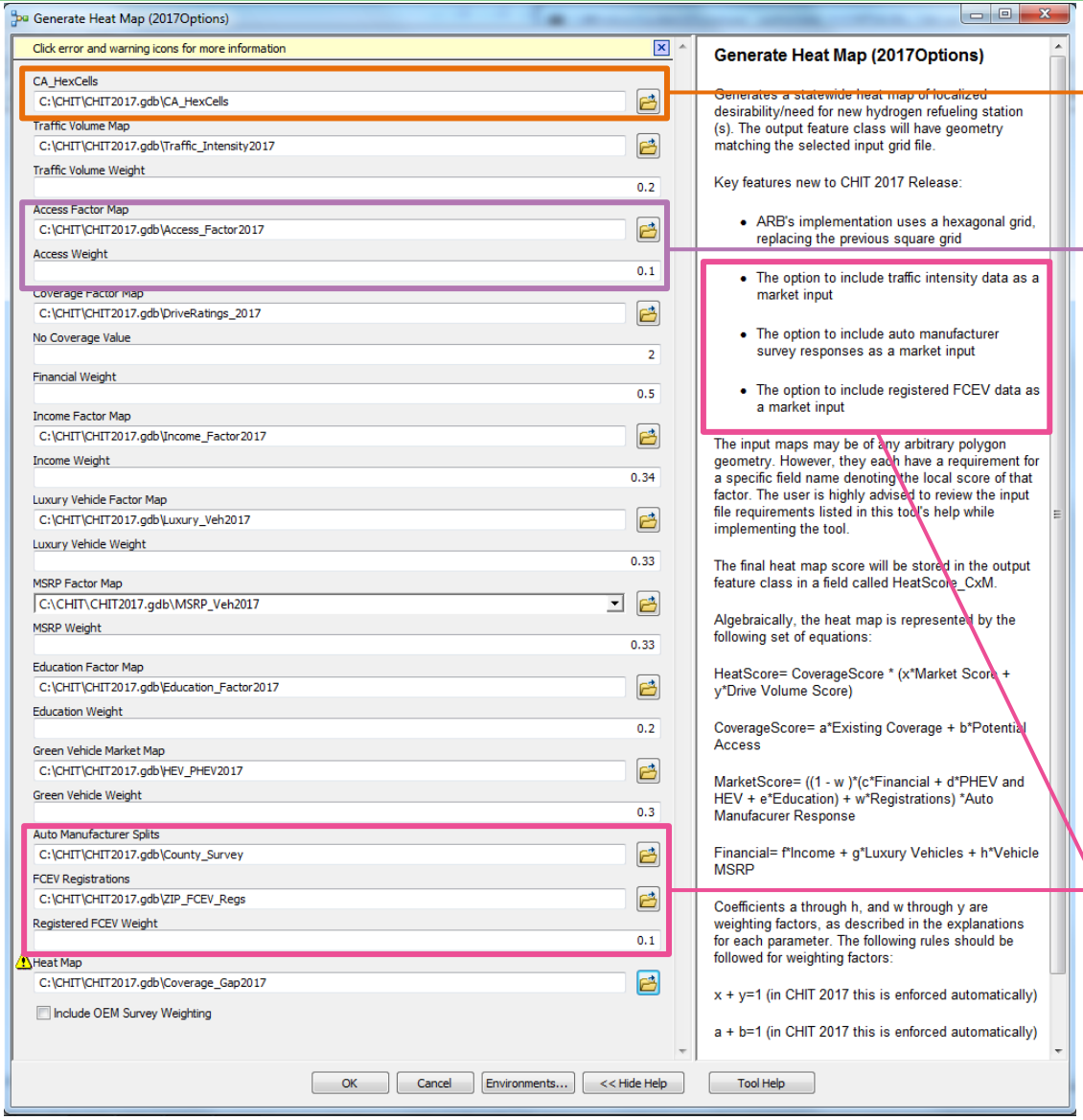
CHIT 2017 TOOLBOX OVERVIEW

CHIT 2017 Toolbox

- Prior unreleased tools
- New tools developed for GFO-15-605 support
- New tools developed based on stakeholder feedback
- New tools developed for 2017 Annual Evaluation
- Process improvements



CHIT 2017 Toolbox



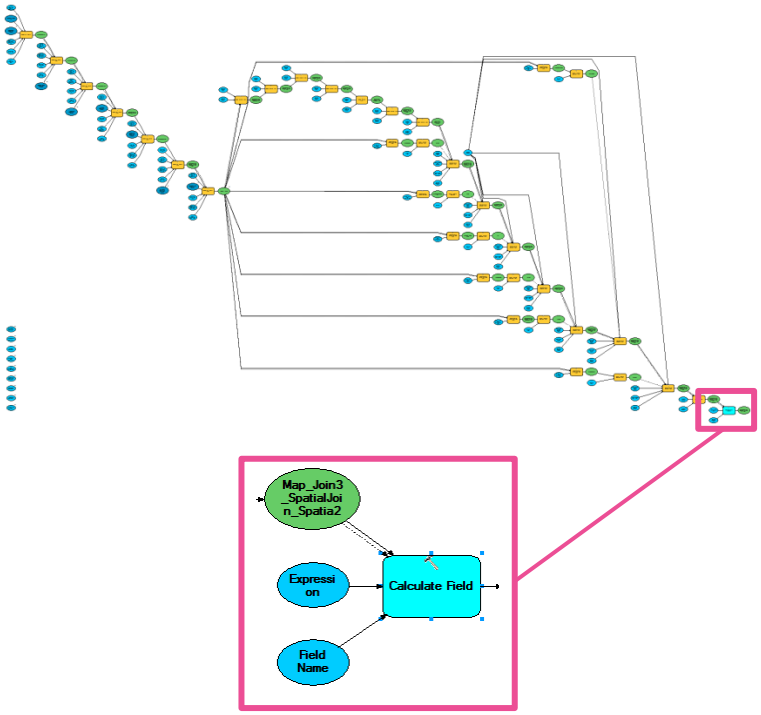
Updated base input data

New functionality options in some tools (See Users Guide v2 for guidance on invoking new features)

New input data options available in some tools

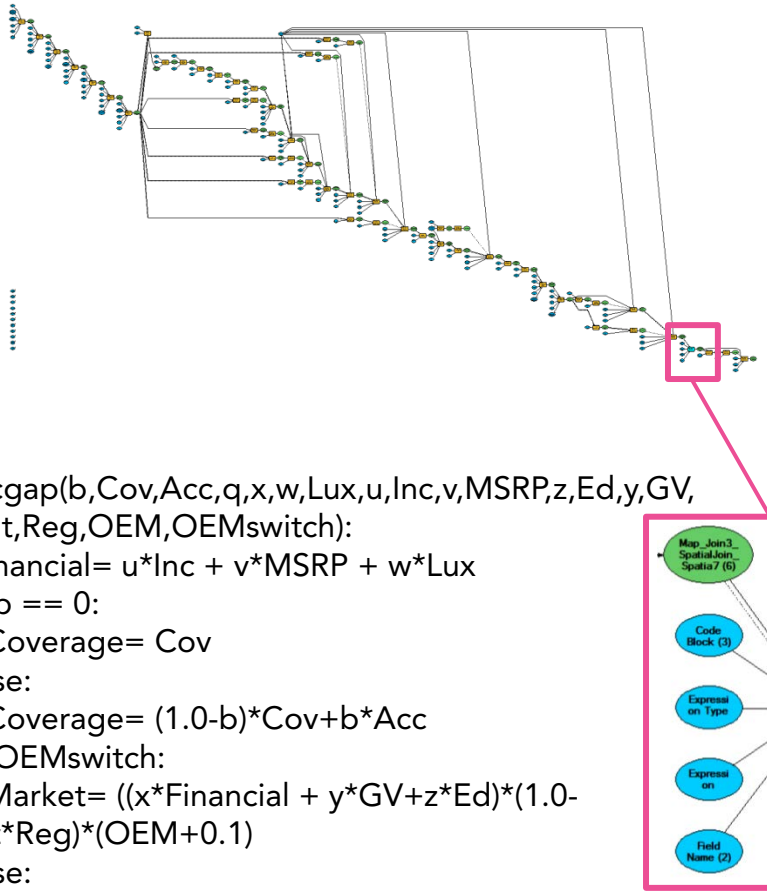
CHIT 2017 Toolbox

CHIT 2015 Release



(%Coverage Weight%* [Rel_Score_DT] +%Access Weight%* [Rel_Score_AC])*(%Financial Weight%*(%Luxury Vehicle Weight%* [Rel_Score_LV] +%Income Weight%* [Rel_Score_Inc]+%MSRP Weight%* [Rel_Score_MSRP])+%Education Weight%* [Rel_Score_Ed]+%Green Vehicle Weight%* [Rel_Score_GV])

CHIT 2017 Release




```
def
calcgap(b,Cov,Acc,q,x,w,Lux,u,Inc,v,MSRP,z,Ed,y,GV,
Vol,t,Reg,OEM,OEMswitch):
  Financial= u*Inc + v*MSRP + w*Lux
  if b == 0:
    Coverage= Cov
  else:
    Coverage= (1.0-b)*Cov+b*Acc
  if OEMswitch:
    Market= ((x*Financial + y*GV+z*Ed)*(1.0-
t)+t*Reg)*(OEM+0.1)
  else:
    Market=(x*Financial+y*GV+z*Ed)*(1.0-t)+t*Reg
  if b == 0:
    Market = Market * Acc
  CovGap= Coverage*((1.0-q)*Market+q*Vol)
  return CovGap
```

CHIT 2017 Toolbox

CHIT 2015 Release

- CHIT_Final.gdb
  - TestNet_2
    - ITN_TIGER_Junctions
    - ITN_TIGER_Roads
    - TestNet_2_ND
    - TestNet_2_ND_Junctions
  - BlockGrp15Min
  - CA_BlockPopulations
  - CA_Gridded
  - Education_Tract_2013ACS_5Yr_Project
  - IDW_Stat_Acc_Poly
  - Income_Tract_2013ACS_5Yr_Project
  - LocalConsumption_DrivePolys
  - LocalConsumption_Facilities
  - Luxury_Veh_ZIPs
  - PMPK_Proj_Junctions
  - TIGER_ITN_PMPkSp_Proj
  - Update_Stations_022715
  - Vehicle_Sales_Bracket_Project
  - ZIP_HEV_BEV_PHEV_Project
- CHIT_Scratch.gdb
  - AB82017_CoverExtent
  - Blockgroup_Facilities
  - Blockgroup_Facilities_012717
  - Blockgroup_Facilities_Backup
  - CA_Polygon
  - CA_Polygon_Proj2
  - CA_Polygon_Proj3
  - CensusUrbAreas
  - Connector_Coverage
  - County_DemandProp
  - CountyBalance_2016Report
  - CountyDemand_2016Report
  - Coverage_Gap_2017_Web
  - CSULA_Only15
  - DMV_2016_ByZIP
  - Drive_Ratings
  - Drive_Ratings_Connector
  - Drive_Ratings012717
  - Drive_Times
  - Drive_Times012717

- Consolidate 2 gdb's to 1
- Add new data layers
- Simplified Naming

CHIT 2017 Release

- CHIT2017.gdb
  - ITN_TIGER_2017
    - ITN_TIGER_2017_ND
    - ITN_TIGER_2017_ND_Junctions
    - ITN_TIGER_Junctions
    - ITN_TIGER_Roads
  - Access_Factor2017
  - AddedStation_DrivePolys
  - BlockGroup_15Min
  - BlockGroups_CHIT2017
  - CA_BlockPopulations
  - CA_HexCells
  - CA_HexCells_Cap
  - CA_Poly_Project
  - Consumption_SeedPoints
  - Consumption_SeedPoints_Temp
  - County_Survey
  - Coverage_Gap2017
  - DriveRatings_2017
  - DriveRatings_PostAddition
  - DriveTimes_2017
  - Education_Factor2017
  - Final_Priority
  - HEV_PHEV2017
  - Hot_Spots
  - Income_Factor2017
  - Local_CapacityNeeds
  - LocalNeedsIDW
  - Luxury_Veh2017
  - Market_FinalPriorities
  - Market_Map
  - Market_PriorityAreas
  - MarketHot_Spots
  - MSRP_Veh2017
  - Priority_Areas
  - PriorityArea_Stations
  - Stations_CHIT2017
  - Test_Join_Temp2017
  - Test_Join2017
  - Tracts_CHIT2017
  - Traffic_Intensity_Weighted
  - Traffic_Intensity2017
  - ZCTA_2017
  - ZIP_FCEV_Regs

SIMULATED TRAFFIC INTENSITY

Traffic Intensity Changes CHIT Fundamentals

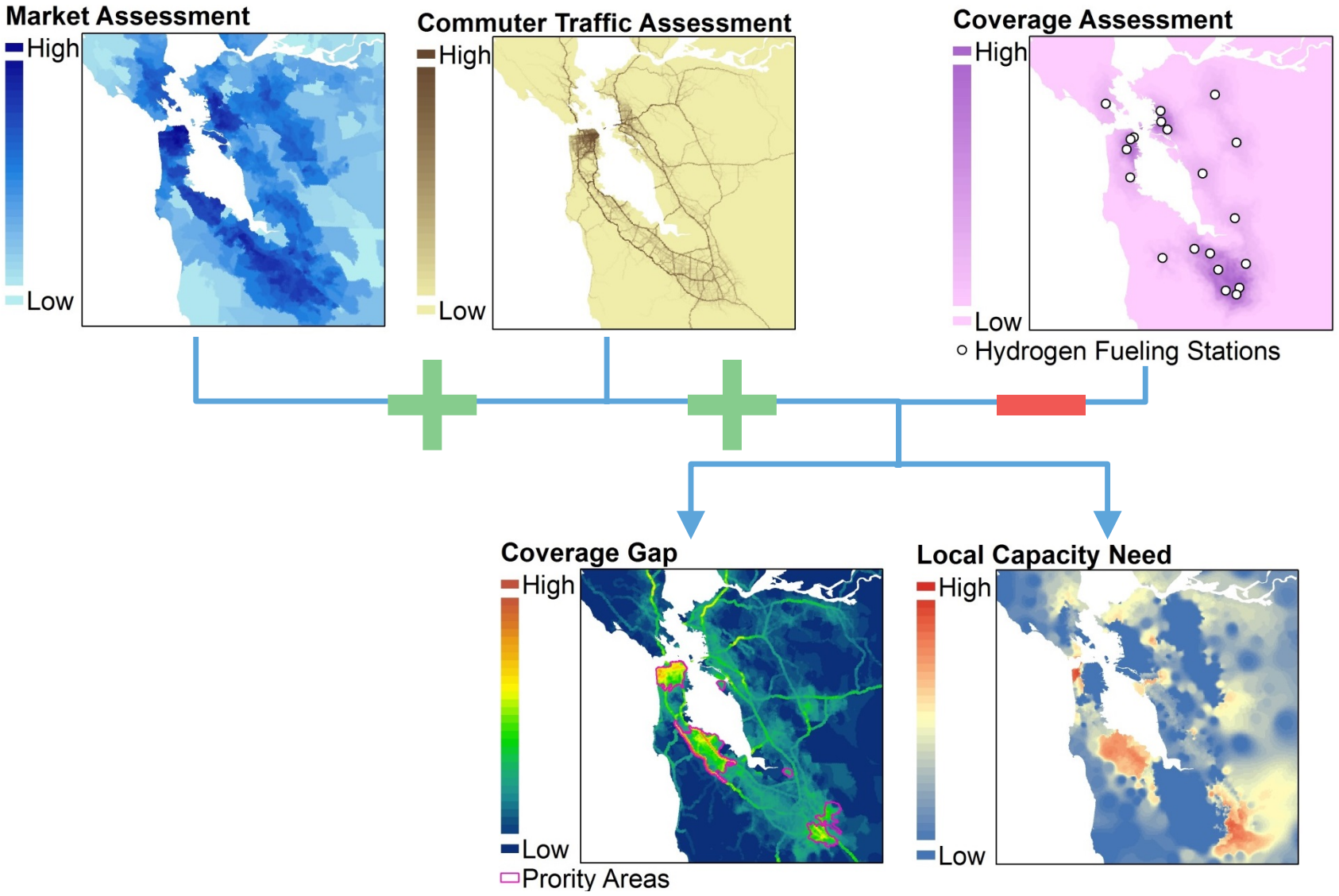
- Principle #6 (2015): Coverage matches the market when it provides convenient fueling access near FCEV drivers' homes

- **Principle #6 (2017): Coverage matches the market when it provides convenient fueling access near FCEV drivers' homes and/or within proximity to commonly-traveled routes**

- Principle #4 (2015): Identification of the FCEV market can be estimated by consideration of the relative distribution of multiple demographic indicators

- **Principle #4 (2017): Identification of the FCEV owner market can be estimated by consideration of the relative distribution of multiple demographic indicators; the total fueling market potential can be estimated by consideration of both the owner market and commonly-traveled routes**

CHIT 2017 Release Structure Revised

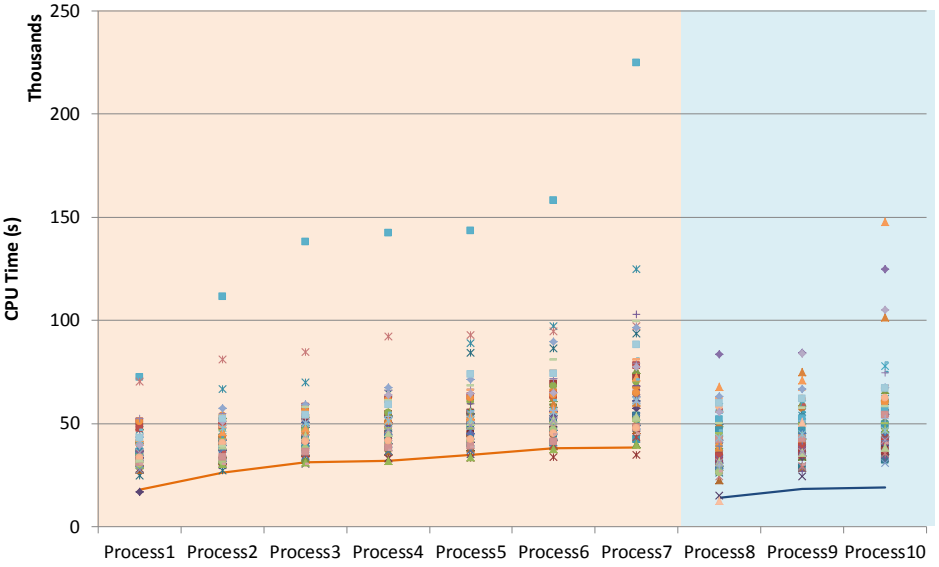


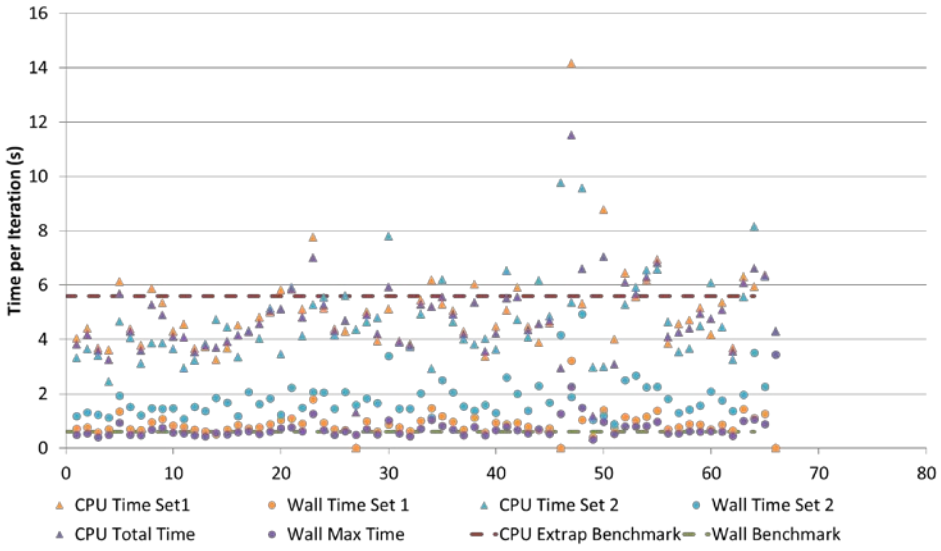
Simulation Concept

- Given a sufficiently-detailed street geometry and travel speed data (provided by ITN-TIGER)…
- Availability of Origin-Destination data for commutes may enable route simulation…
- However, simulated data requires elevated scrutiny compared to observational data
- Major lead: Stakeholder suggestion at October 2015 webinar to look into LODES (LEHD Origin-Destination Employment Statistics) data set

Method

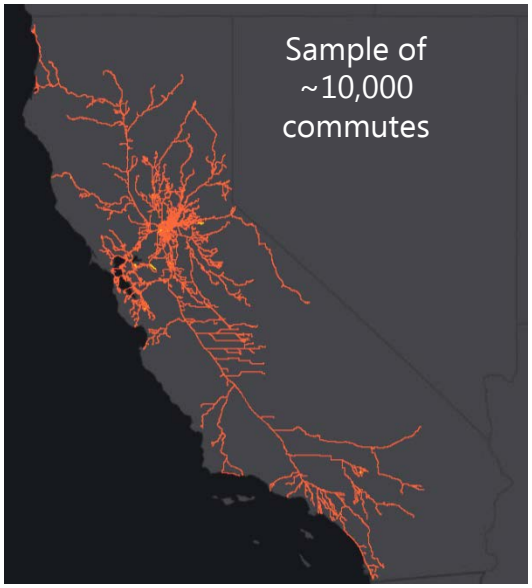
- Step 1: Simulate all entries in the LODES data file
  - Geocode census block centroids and extract x/y to be able to load origins and destinations in Network Analyst
  - Use Network Analyst to simulate PM commute routes of all entries
    - Inherently assumes travel time optimization
  - Large processing effort: ~7.6 million records for ~8.36 million commutes
  - Executed via stand-alone arcpy across 10 processors on 2 computers
  - Batch processed 10,000 routes on each processor at a time: ~6 months

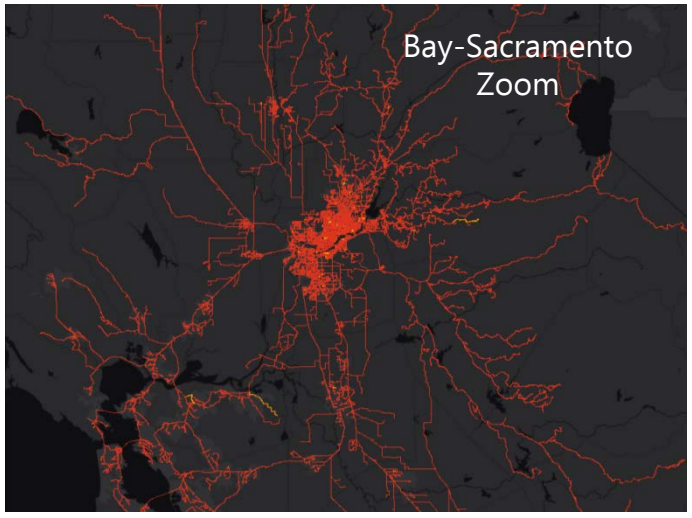


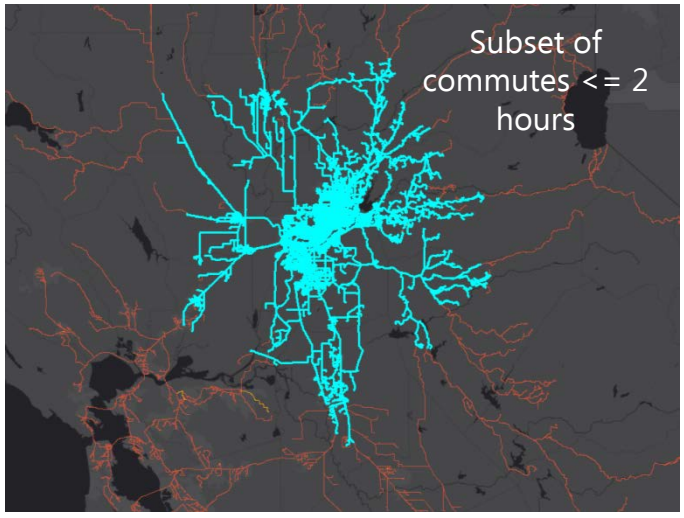


Method

- Step 2: Combine data from resulting ~760 files
  - Down-select within each file to routes with 2 hours or less drive time
  - Spatially join with analysis grid
  - Keep running total of number of commutes through each cell
  - Smaller computing effort: python script executed in ArcMap
  - Batch processed over ~3 weeks

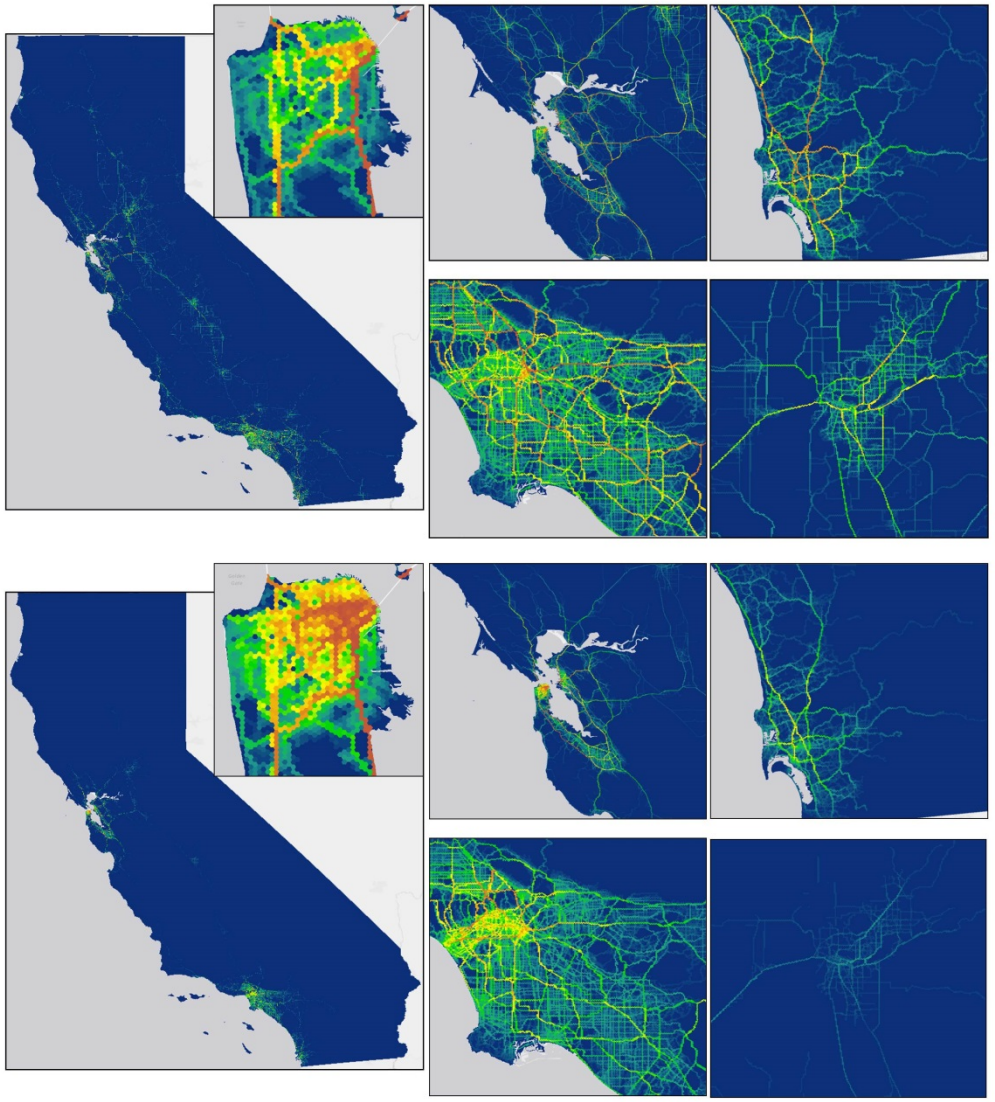






Method

- Step 2, adjusted: Combine data and weight each drive according to home-based market potenti
  - Concept was suggeste at March webinar and received positive stakeholder feedback
  - Allows traffic data to more selectively reflec FCEV first adopters' lik driving patterns
  - Due to time constraint uses 2015 market assessment
  - Both data sets availabl in CHIT 2017 for user implementation



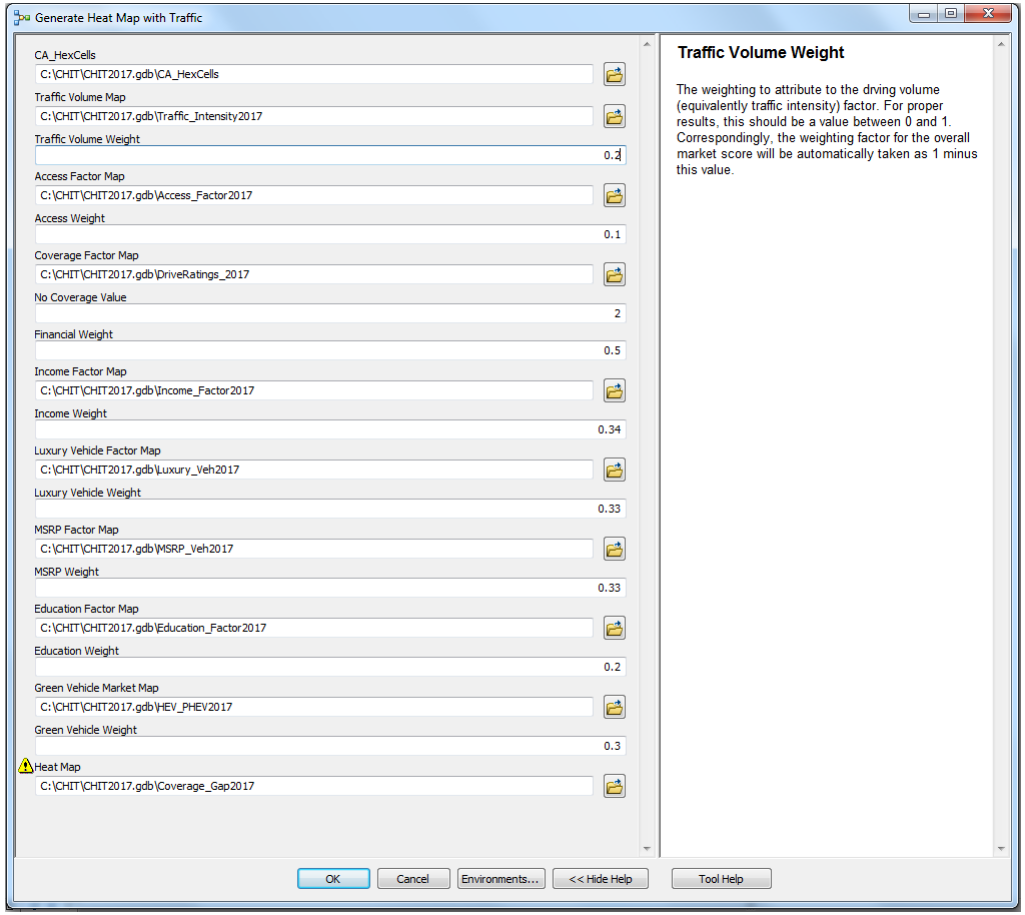
Recap of Simulated Data Set

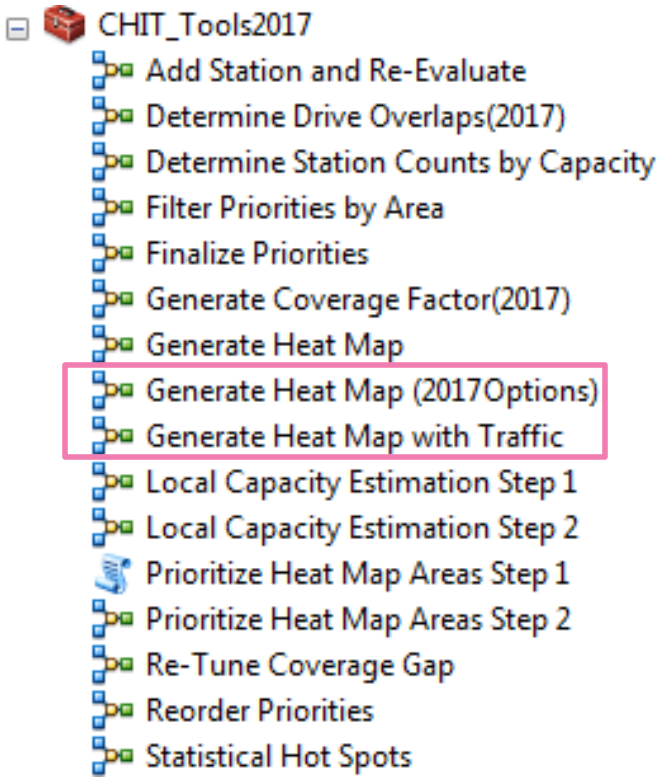
- What the simulated traffic data **DOES** provide:
  - Detailed routing information, based on speed data at fine resolution
  - The optimized travel route for the simulated commuters, given the input speed data
  - A reasonably-sized sample of the full labor force
    - US Bureau of Labor Statistics estimates ~17.6 million in California's employed work force in late 2014
  - An estimate of what the relative commuter traffic intensity might be in different locations throughout the state
  - A unified estimate that is similarly developed for all locations in the state
  - An estimate of traffic volume that is self-consistent with traffic speeds already implemented in CHIT

Recap of Simulated Data Set

- What the simulated traffic data **DOES NOT** provide:
  - Observed, actual routes of commuters
  - The full commuter travel pattern
  - Travel patterns of non-commuter vehicles
    - Occupational, Medium-Duty, Heavy-Duty, and other vehicles not included
    - The traffic patterns of these vehicles can affect Light-Duty commuter traffic
    - The intricacies and interactions are not accounted for
  - An assessment of commuter travel via public transportation or other modes
  - Any indication of the travel routes specifically utilized by first adopters
  - Exact door-to-door routes

Using Traffic Data





Traffic data implementation available in fully revised Heat Map tool (2017 Options). Also available as only additional data option (Heat Map with Traffic) to avoid additional processing time for all options in fully revised tool.

Revised CHIT Coverage Gap Equation

- CHIT 2015:

Heat = Coverage *
Market

Coverage= 0.5 * Existing +
0.5 * Potential

Market= 0.5 * Financial +
0.3 * P/HEV +
0.2 * Education

Financial= 0.34 * Income +
0.33 * MSRP +
0.33 * Luxury

- CHIT 2017 w/ Traffic:

Heat= Coverage *
(0.8 * Market +
0.2 * Traffic Volume)

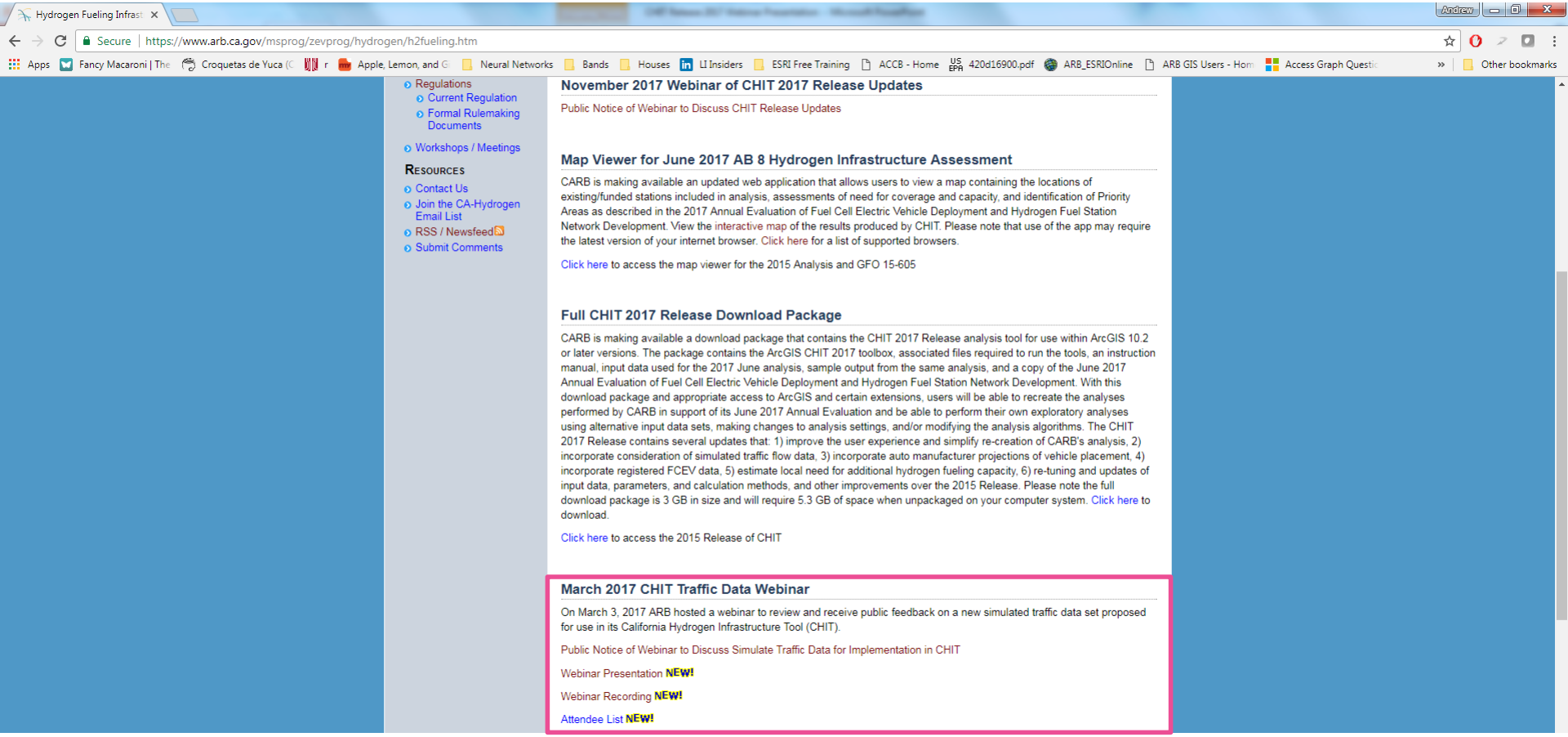
Coverage= 0.9 * Existing +
0.1 * Potential

Market= 0.5 * Financial +
0.3 * P/HEV +
0.2 * Education

Financial= 0.34 * Income +
0.33 * MSRP +
0.33 * Luxury

CHIT Traffic Webinar

- For more information, see:
  https://www.arb.ca.gov/msprog/zevprog/hydrogen/h2fueling.htm



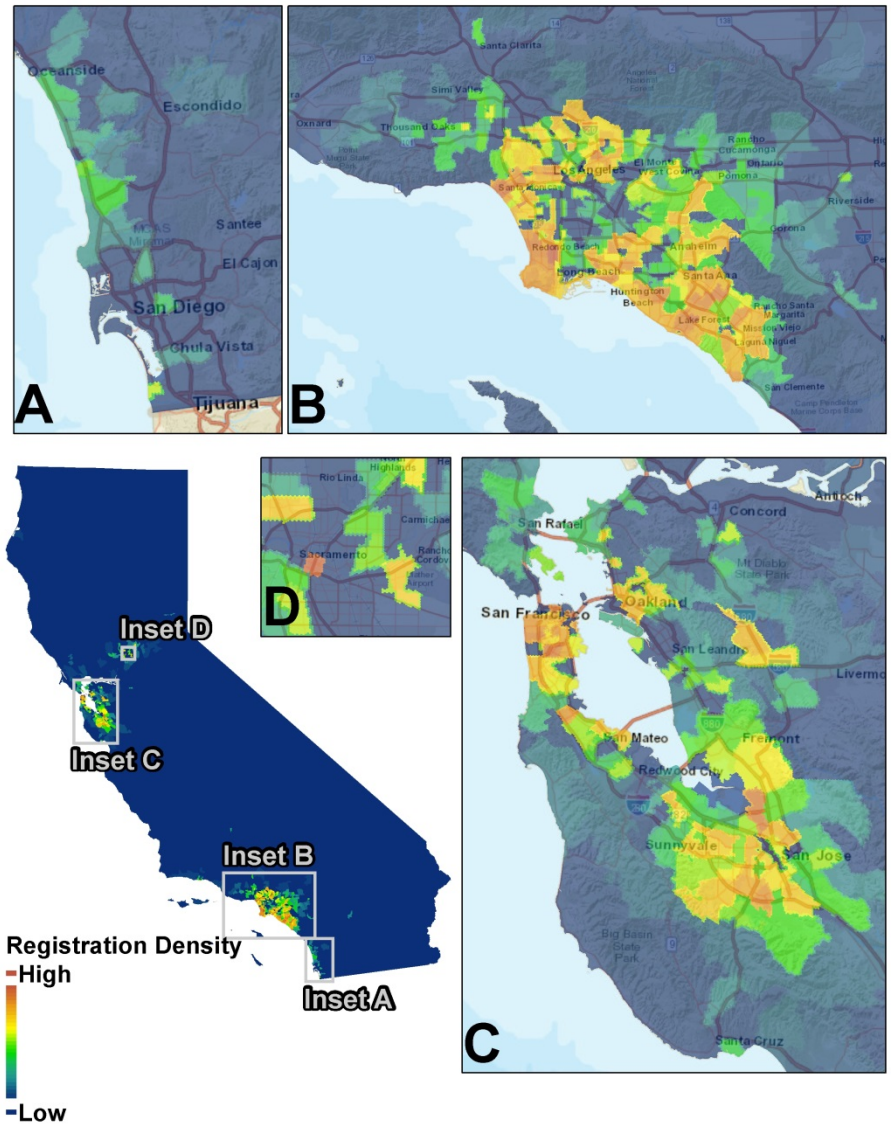
AUTO MANUFACTURER SURVEY AND DMV DATA

Concepts and Motivations

- DMV Registration Data
  - Historically, CHIT and other tools have been intended to analyze forecasted needs for hydrogen fueling
  - No empirical data previously available for existing gaps (other than case-by-case and anecdotal data)
  - As California's network continues to develop, assessment of gaps will need to move away from forecasts and estimates of market potential to empirically-proven market development

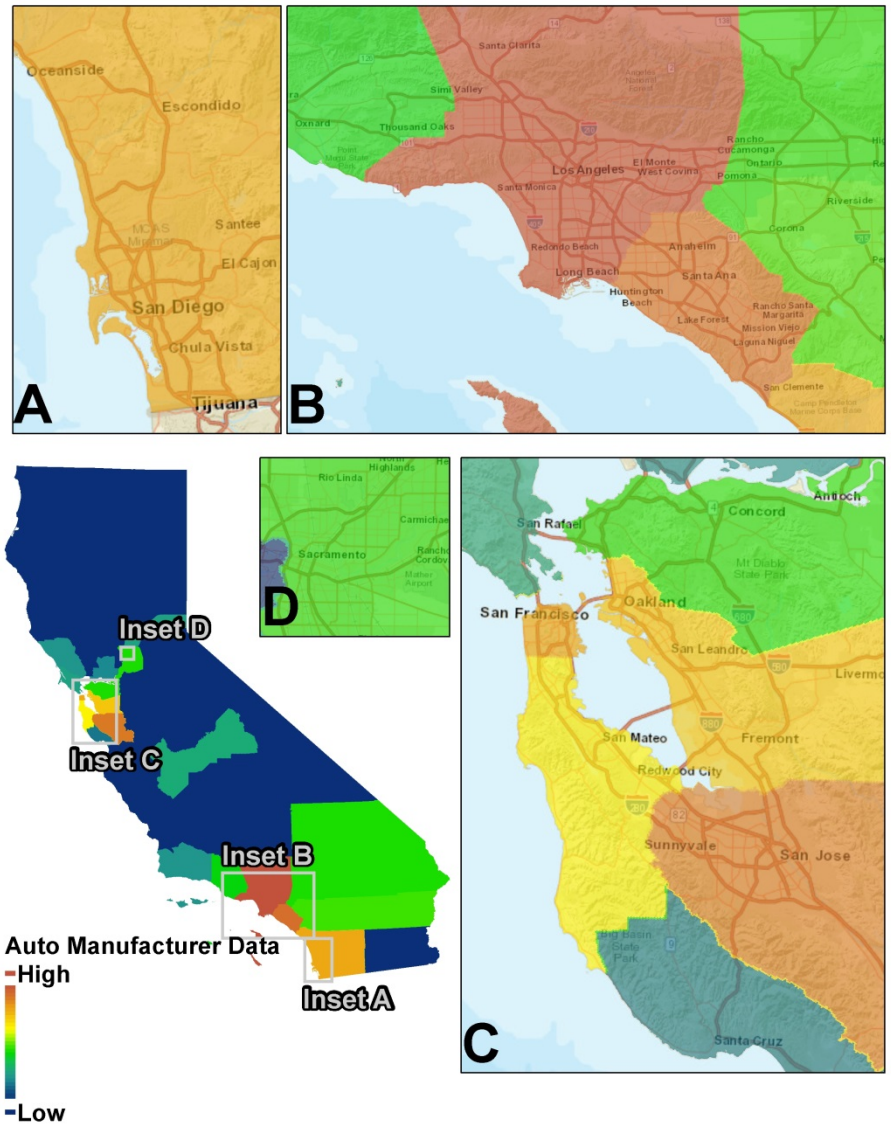
- Auto Manufacturer Data
  - CHIT relies on open, public data sets for forecasting and estimating FCEV market potential
  - Input data elements are limited and likely provide only a portion of the full picture
  - Auto manufacturer survey data is a second, independent assessment and may more closely represent direct FCEV intender market

DMV Registration Data Input



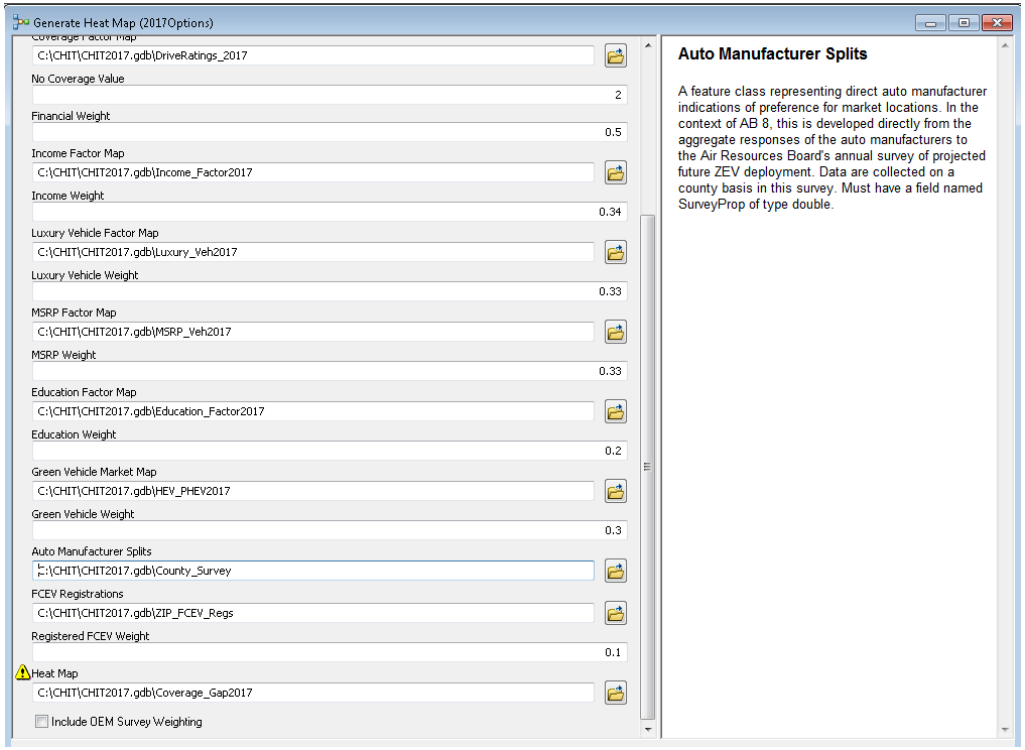
- Based on April 2017 registration data reported in the 2017 Annual Evaluation
- Similar to other market indicators, use spatial densities of vehicle deployments on a ZIP-code basis (count/sq mi)
- Total of 1,609 FCEVs throughout the state
- Applied to market evaluation portion of coverage gap as an additive factor with other indicators

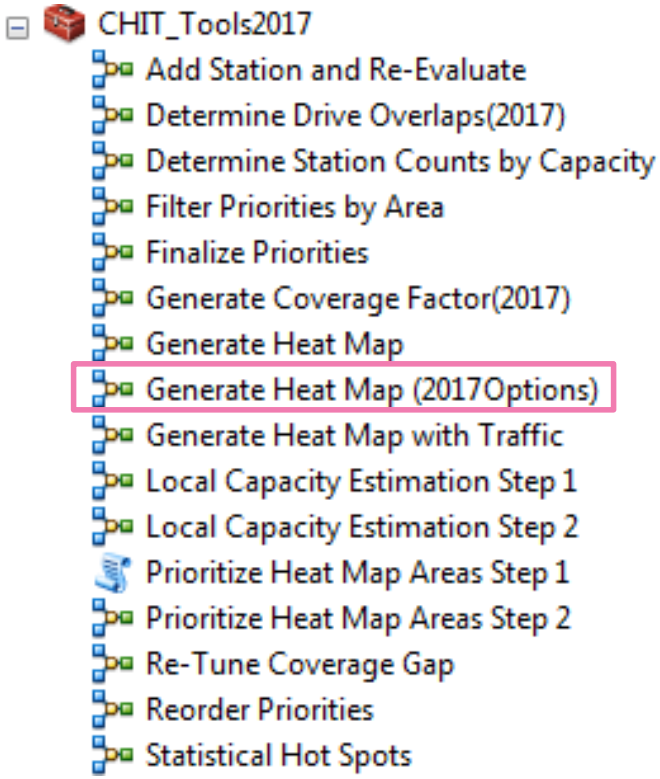
Auto Manufacturer Data Input



- Based on April 2017 auto manufacturer survey data, administered under the AB 8 program and reported in the 2017 Annual Evaluation
- Spatial resolution is limited by the format of the survey (county-level)
- Due to low spatial resolution, data are not considered on an area density basis
- Applied as overall scaling factor to market evaluation

Using FCEV Deployment Data





DMV and auto manufacturer implementation available in fully revised Heat Map tool (2017 Options).

Auto manufacturer data implemented as a switch (see next slide).

Revised CHIT Coverage Gap Equation

- CHIT 2015:

Coverage Gap = Coverage * Market

Coverage= 0.5 * Existing + 0.5 * Potential

Market= 0.5 * Financial + 0.3 * P/HEV + 0.2 * Education

Financial= 0.34 * Income + 0.33 * MSRP + 0.33 * Luxury

- CHIT 2017 w/ all Optional Data:

Coverage Gap= Coverage * (0.8 * Market + 0.2 * Traffic Volume)

Coverage= 0.9 * Existing + 0.1 * Potential

Market= 0.9 * (0.5 * Financial + 0.3 * P/HEV + 0.2 * Education) + 0.1 * DMV Regs

or (if Auto Data Switch Set):

Market= (0.9 * (0.5 * Financial + 0.3 * P/HEV + 0.2 * Education) + 0.1 * DMV Regs) * Auto Data

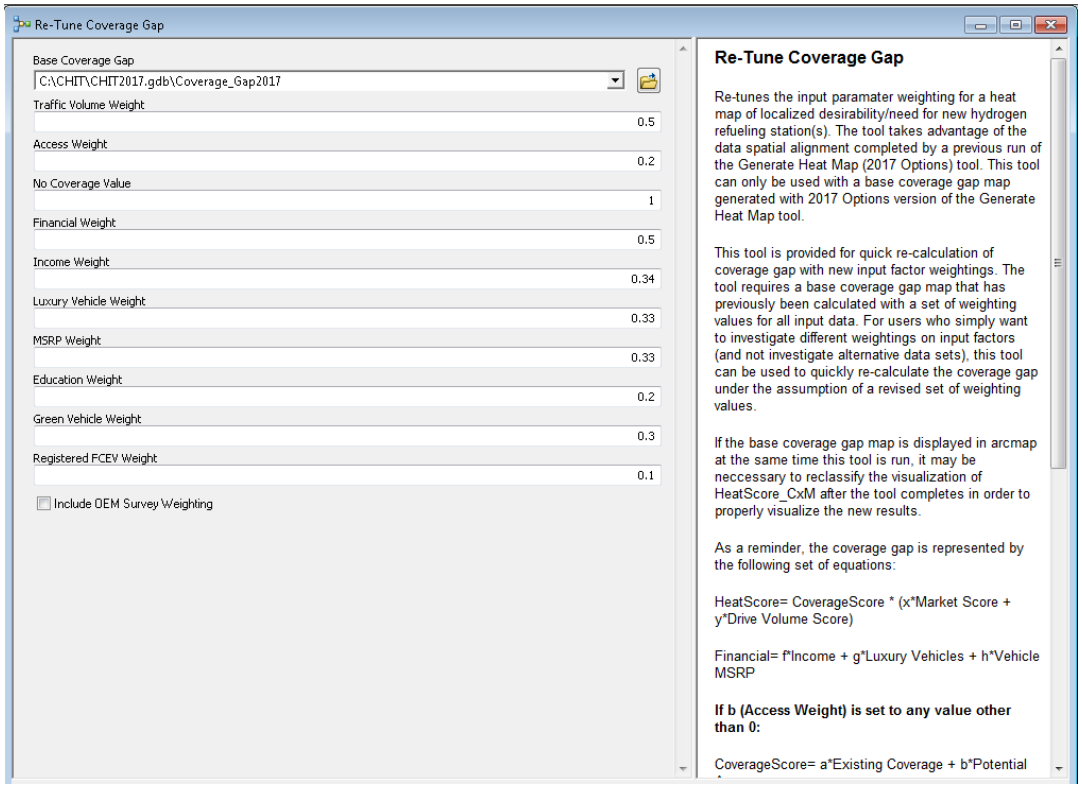
Financial= 0.34 * Income + 0.33 * MSRP + 0.33 * Luxury

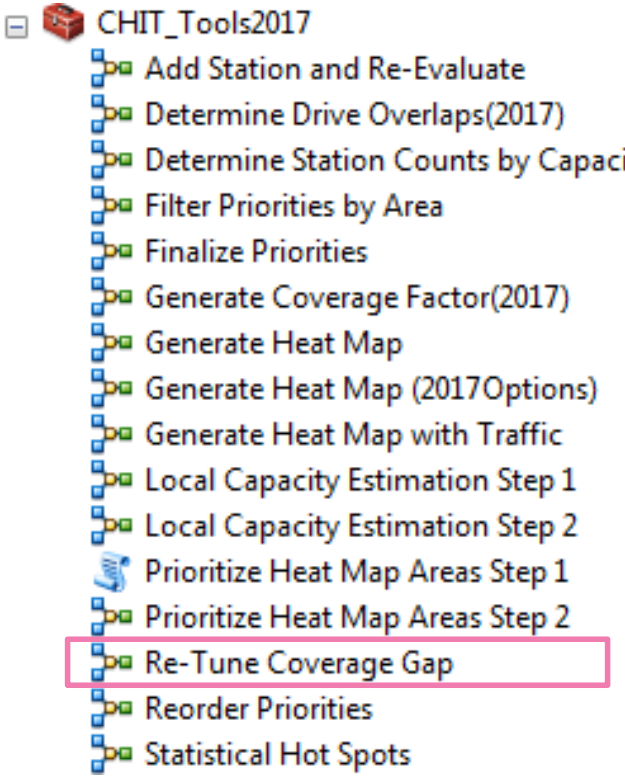
COVERAGE GAP RE-TUNING

Motivation

- CHIT 2017 Release expands the possible options for input data considered, all associated with individual weighting factors
- CHIT users may be interested in sensitivity analyses to assess the appropriate weighting factor for each input data set
- Full coverage gap calculation hours long because of aligning and joining of several data inputs
- However, for a re-calculation, do not need to perform spatial aligning if base data sets remain the same
- New tool takes advantage of this to complete a coverage gap re-assessment in a short period

Using Re-Tuning Tool

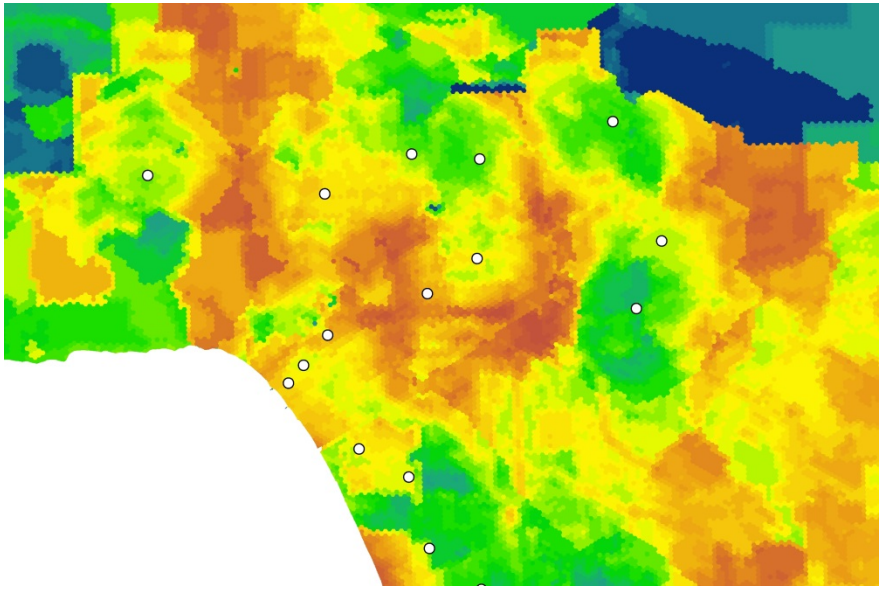


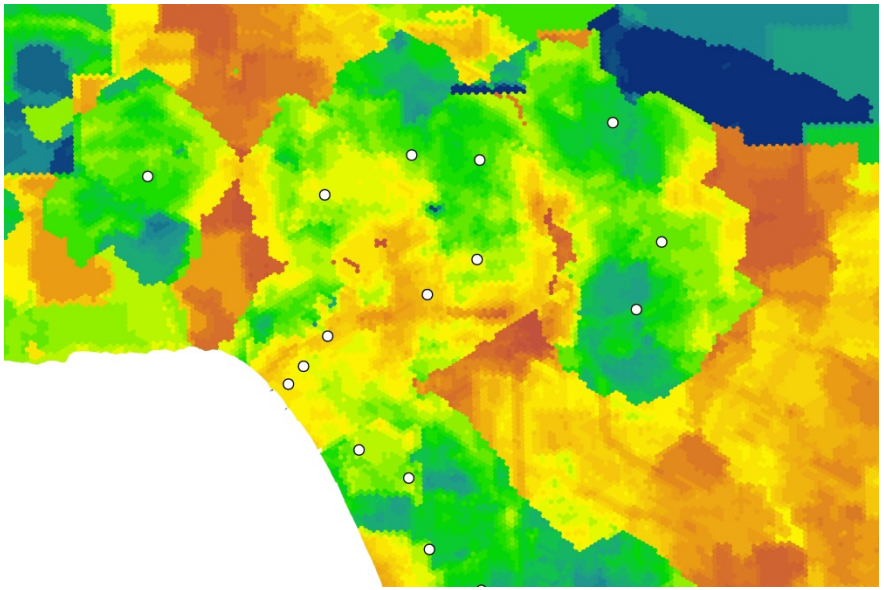


NOTES:

- Base Coverage Map must be developed only with the Generate Heat Map (2017 Options) tool (or the Re-Tuning tool beginning with such a map)
- The No Coverage Value parameter is defined *relative* to the value used to calculate the Base Coverage Map
- This tool modifies the Base Coverage Map file. It does not generate a new feature class; users should backup the Base Coverage Map if it is desirable to keep the base map

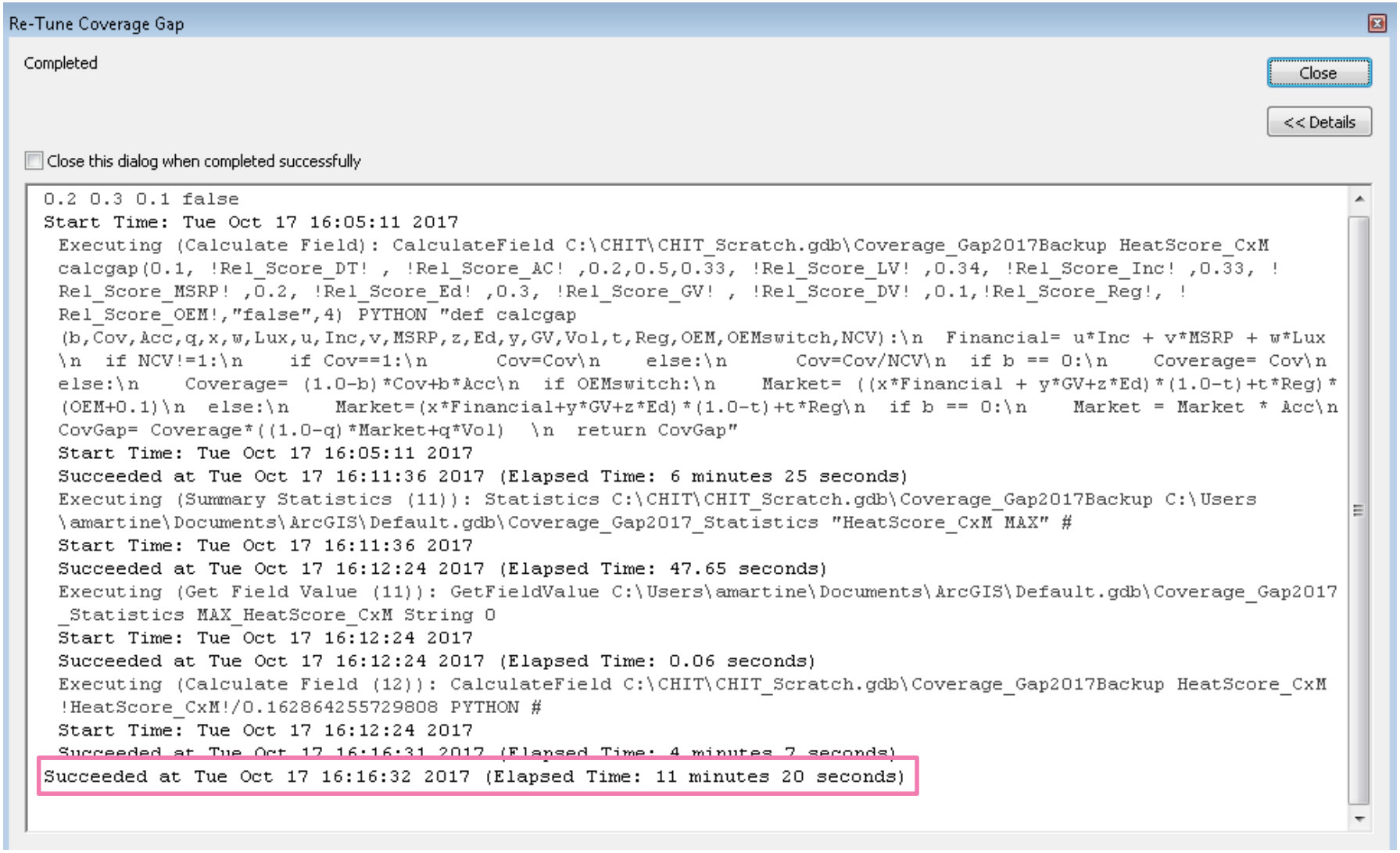
Example of Retuning





- Example shows Coverage Gap as calculated in 2017 Annual Evaluation in West LA region in top figure
- Bottom figure shows effect of quadrupling the priority placed on areas with no coverage provided at all (by setting the No Coverage Value in the Re-Tuning Tool to 4)
- White dots indicate locations of funded stations

Example of Retuning

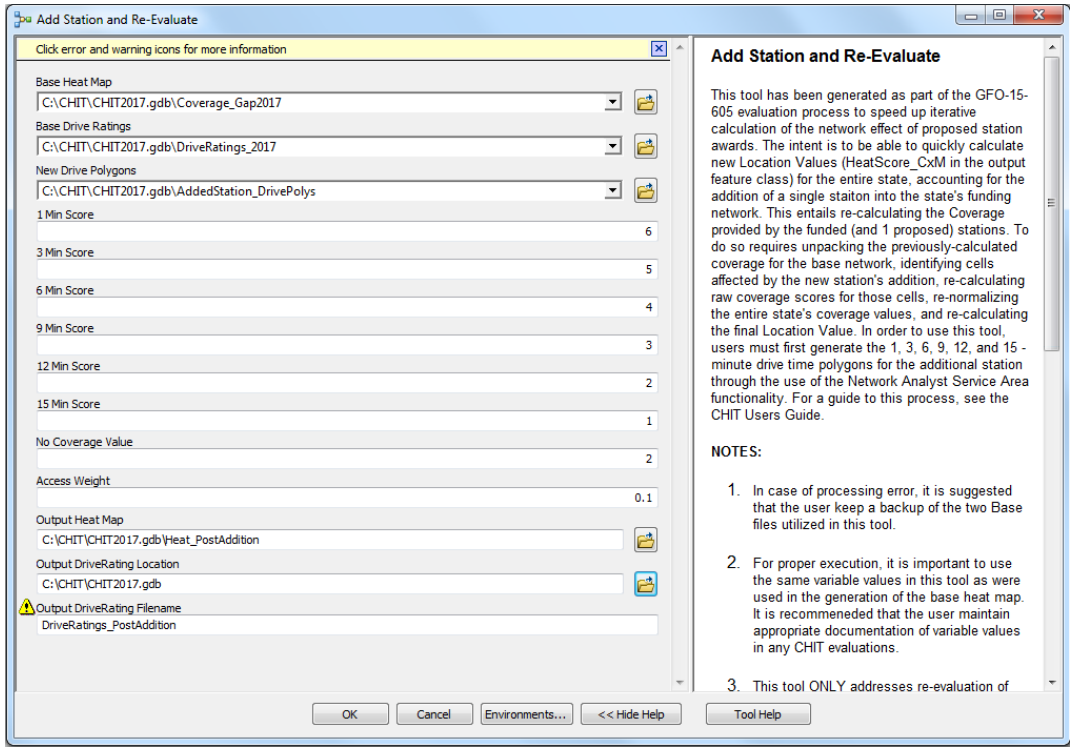


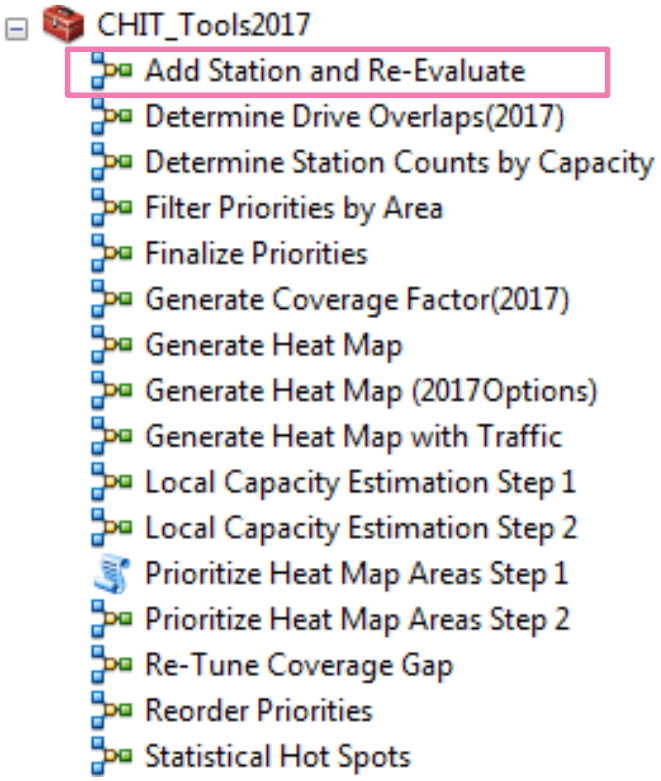
SINGLE STATION RE-EVALUATION

Motivation

- First developed as a tool to quickly implement iterative evaluation process of GFO-15-605
  - GFO-15-605 first solicitation where the "network effect" of each proposed award explicitly evaluated
  - After a station award selected, CHIT data (coverage gap and capacity need) adjusted to account for impact of that station
  - All stations' Coverage, Capacity, and Market Viability scores reconsidered on the basis of this updated analysis
  - Repeated for every award in NOPA-15-605 (each iteration referred to in NOPA as a "CHIT Round")
- Full coverage gap calculation hours long because of aligning and joining of several data inputs
- However, for a re-calculation, do not need to perform spatial aligning if calculation inputs known
- New tool takes advantage of this to complete a coverage gap re-assessment in roughly 20 minutes

Using Coverage Re-Evaluation

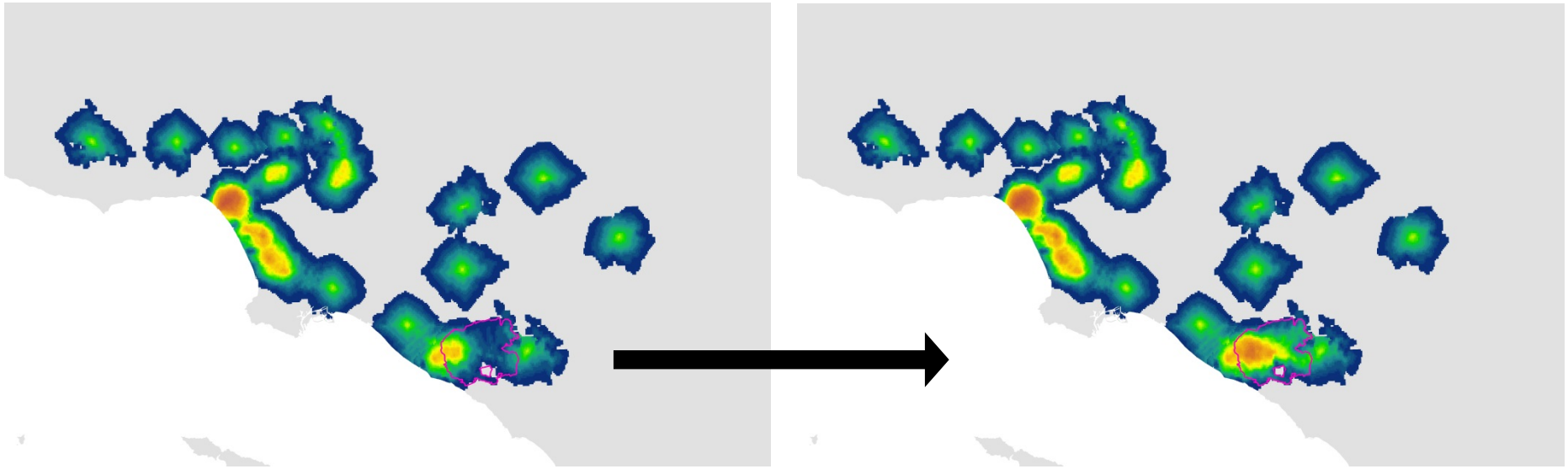




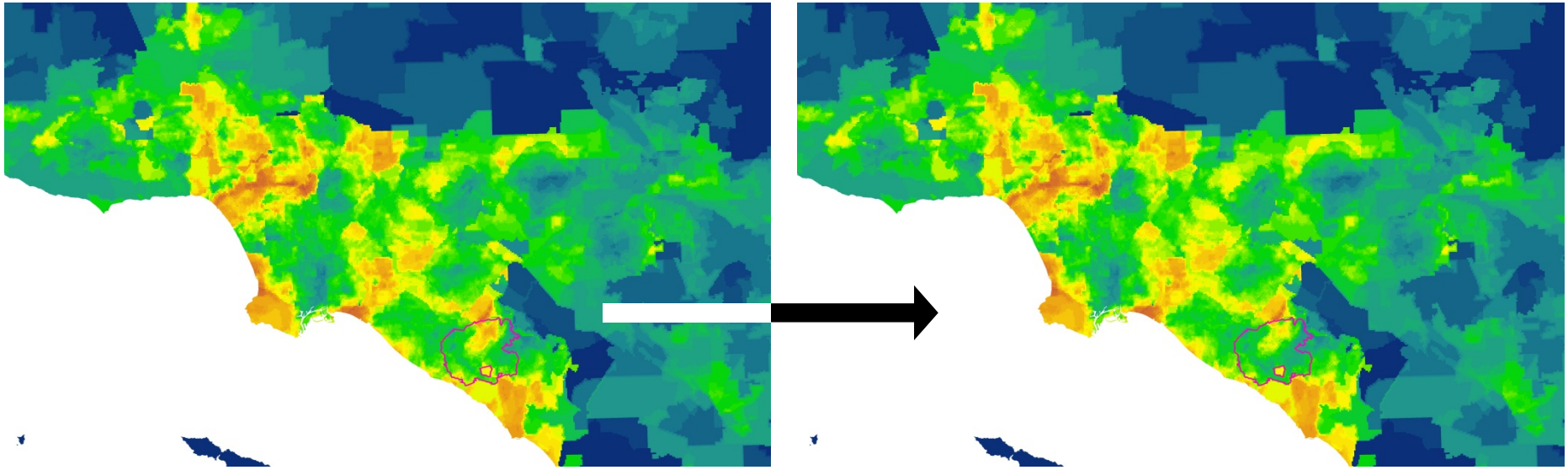
NOTES:

- Must first complete a Service Area calculation for the new station placement
- Able to recalculate Coverage Gap map generated with any version of Generate Heat Map
- Does not make any adjustment to market side of evaluation
- Does not re-calculate capacity need
- Faster than full Generate Heat Map process for a single station
- Can be used iteratively for multiple stations though after ~15 stations, this tool is slower

Coverage Re-Evaluation Example



Final GFO 15-605 CHIT Round: Evaluation after Addition of 5333 University Dr (Irvine)



ALTERNATIVE COVERAGE GAP FORMULA

Motivation

- Through the exercise of the iterative evaluation in GFO-15-605, CARB noted that coverage gap was more heavily controlled by population density (captured in the "Potential" Coverage data factor) than initially desired

- CARB performed sensitivity analysis and determined that the weight attributed to this factor (previously 0.5 in CHIT 2015 Release) needed to be exceedingly small in order for population density not to be the most important factor in coverage gap evaluations

- CARB proposed that another solution was to re-cast the "Potential" Coverage factor as a scaling factor on market evaluation rather than as an additive factor in the coverage evaluation

Alternative CHIT Coverage Gap Equation

- CHIT 2017 w/ all Optional Data:

Coverage Gap= Coverage *
(0.8 * Market +
0.2 * Traffic Volume)

Coverage= 0.9 * Existing +
0.1 * Potential

Market= (0.9 * (0.5 * Financial +
0.3 * P/HEV + 0.2 *
Education) + 0.1 *
DMV Regs) * Auto Data

Financial= 0.34 * Income + 0.33 *
MSRP + 0.33 * Luxury

- CHIT 2017 Alternative:

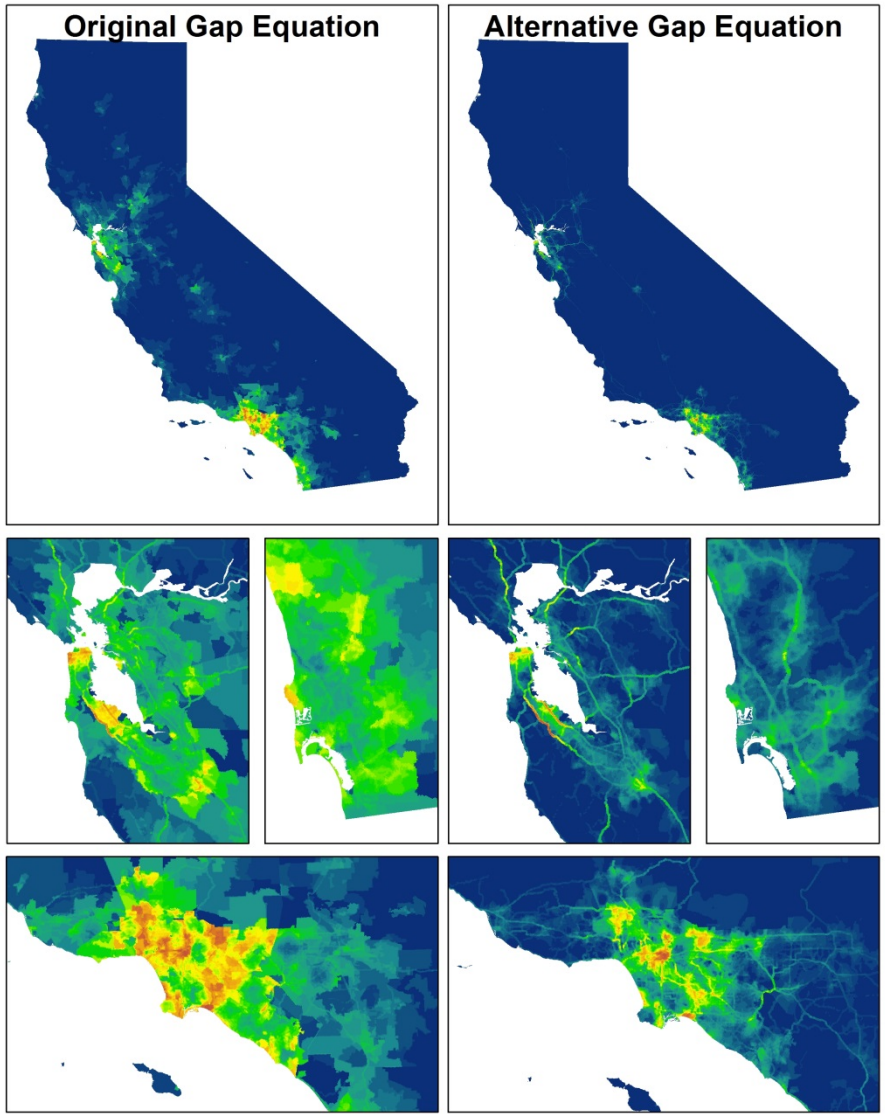
Coverage Gap= Coverage *
(0.8 * Market +
0.2 * Traffic Volume)

Coverage= Existing

Market= (0.9 * (0.5 * Financial +
0.3 * P/HEV + 0.2 *
Education) + 0.1 *
DMV Regs) *
Auto Data * Potential

Financial= 0.34 * Income + 0.33*
MSRP + 0.33 * Luxury

Using Alternative Coverage Gap Formulation



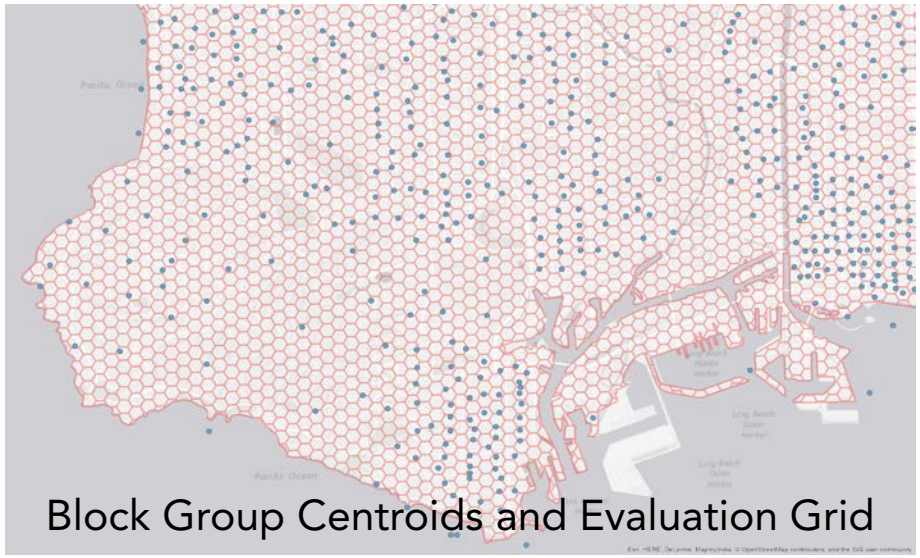
- Can be implemented in Coverage Gap calculation tools (including Re-Tune Coverage Gap) by setting the weight for the Potential Coverage (called "Access Factor" in the tools) to 0
- With all other factor weights left unchanged, CARB found that results were too spatially limited
- 2017 Annual Evaluation does not use this formulation but will continue to be investigated at CARB and provided in tool for stakeholder investigation

LOCAL CAPACITY NEED

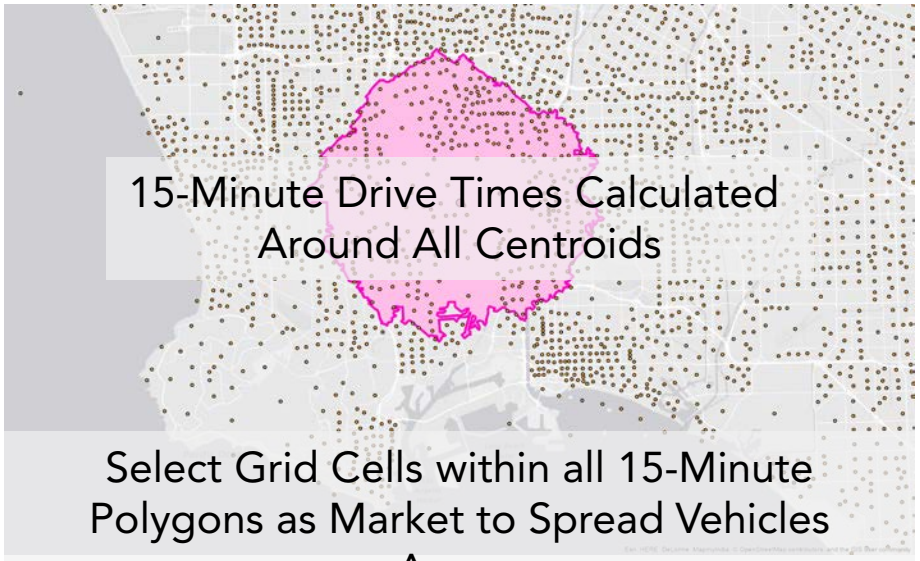
Motivation

- First created to aide decision-making process for GFO 15-605
- Estimates localized capacity need based on auto manufacturer survey data and extent of coverage provided by funded stations
- Capacity need is a localized, continuous value across the state
  - The total of all cells is much larger than the total need for the assumed number of vehicles
  - Interpolation step adds spatial variation according to distance from stations, even outside range of a station's coverage

Capacity Need Estimation Process

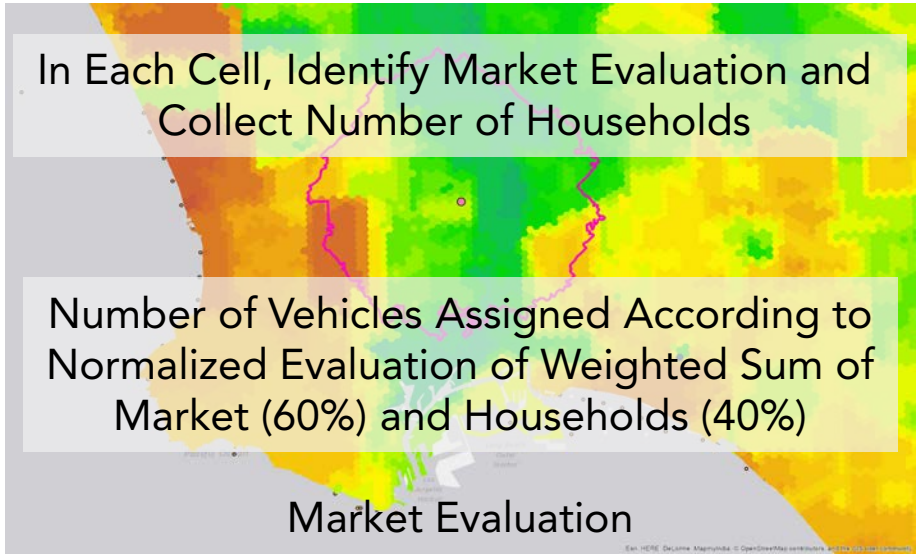


Block Group Centroids and Evaluation Grid



15-Minute Drive Times Calculated Around All Centroids

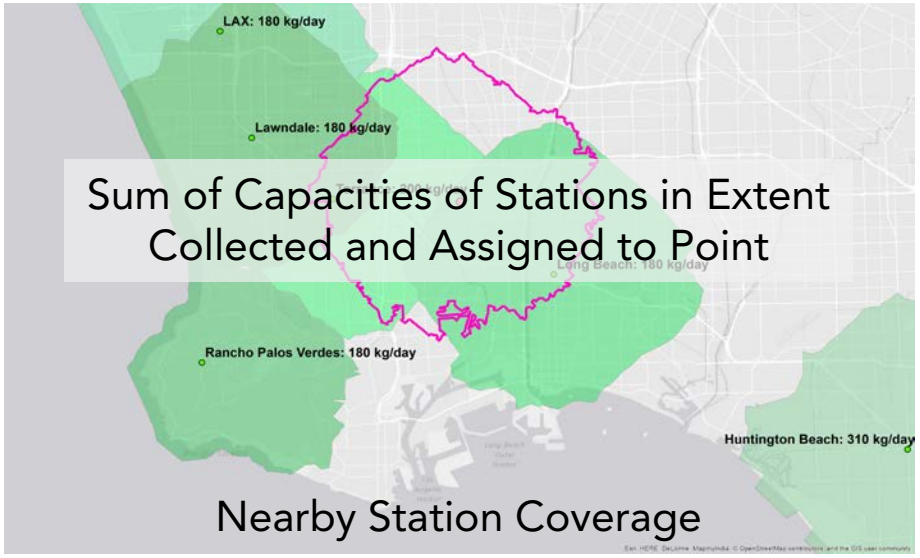
Select Grid Cells within all 15-Minute Polygons as Market to Spread Vehicles Across



In Each Cell, Identify Market Evaluation and Collect Number of Households

Number of Vehicles Assigned According to Normalized Evaluation of Weighted Sum of Market (60%) and Households (40%)

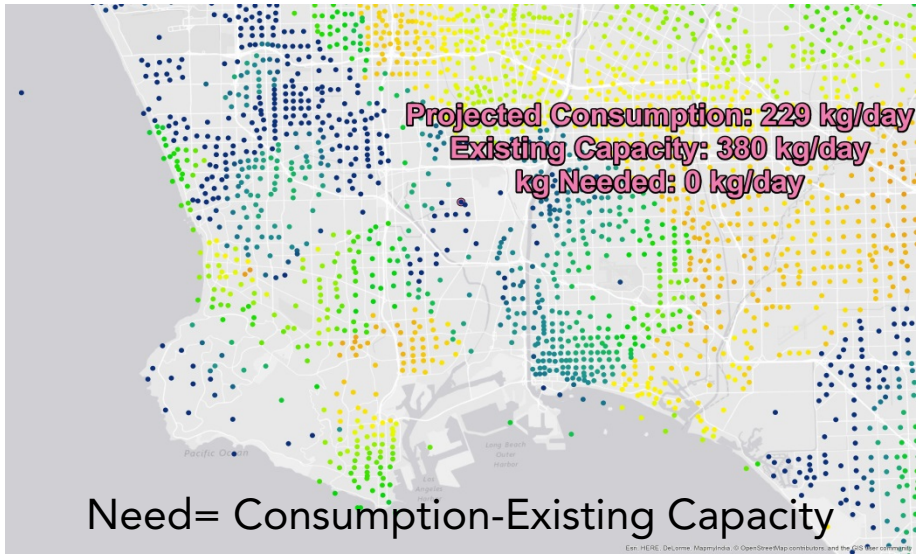
Market Evaluation

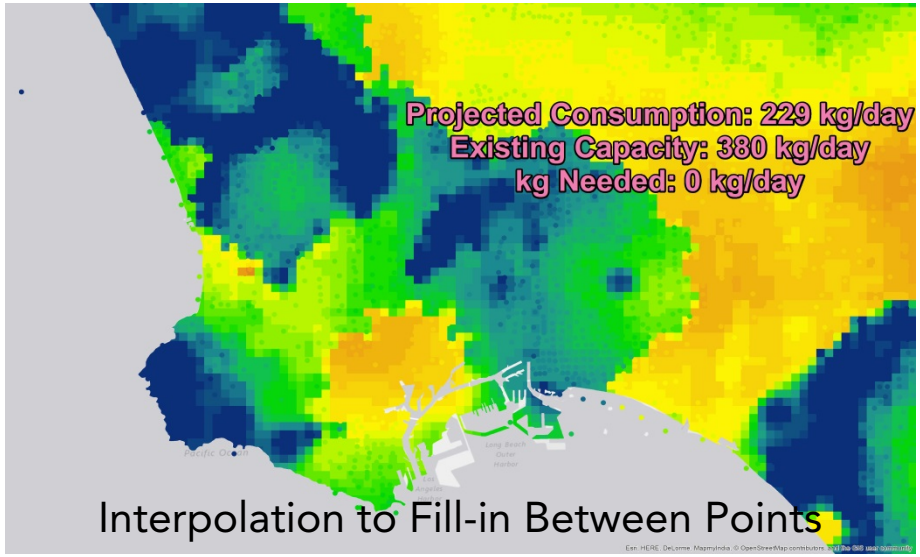


Sum of Capacities of Stations in Extent Collected and Assigned to Point

Nearby Station Coverage

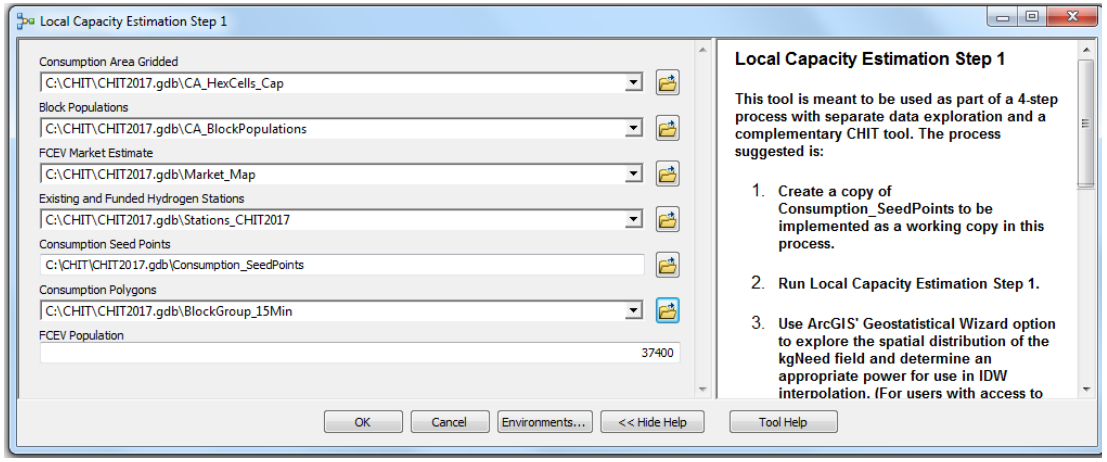
Capacity Need Estimation Process

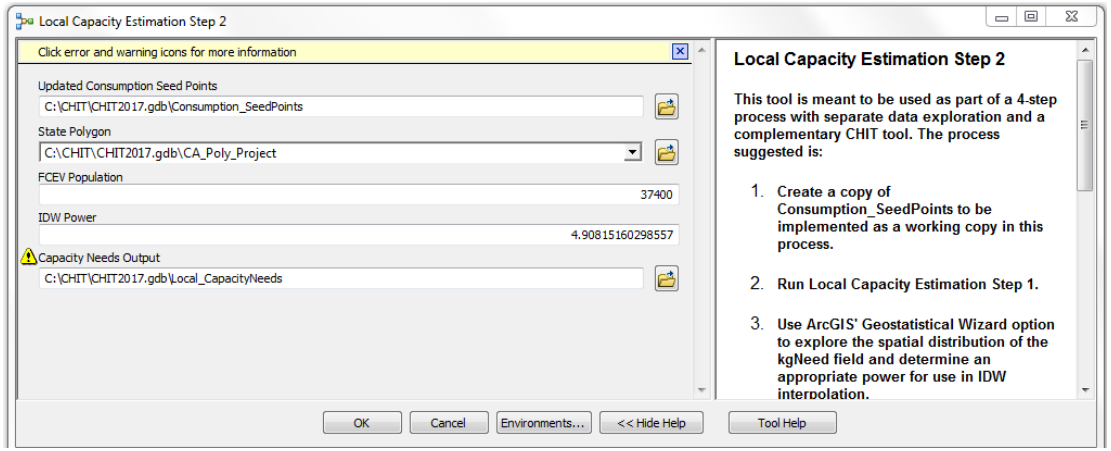


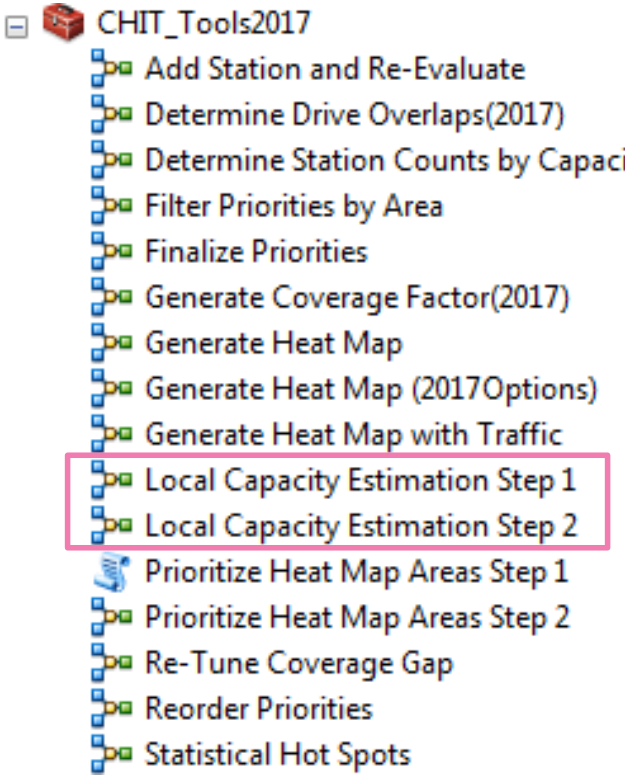


- Interpolation relies on built-in ArcGIS methods
- Process has been divided into two steps to allow tuning of interpolation
- Interested users can explore impacts of re-tuning the interpolation after Step 1
  - Requires access to Geostatistical Analyst Extension
  - Users without this access can either accept defaults or iteratively use trial-and-error in Step 2
  - Step 2 interpolation has been built assuming only Inverse Distance Weighting (IDW) interpolation method

Using Local Capacity Estimation



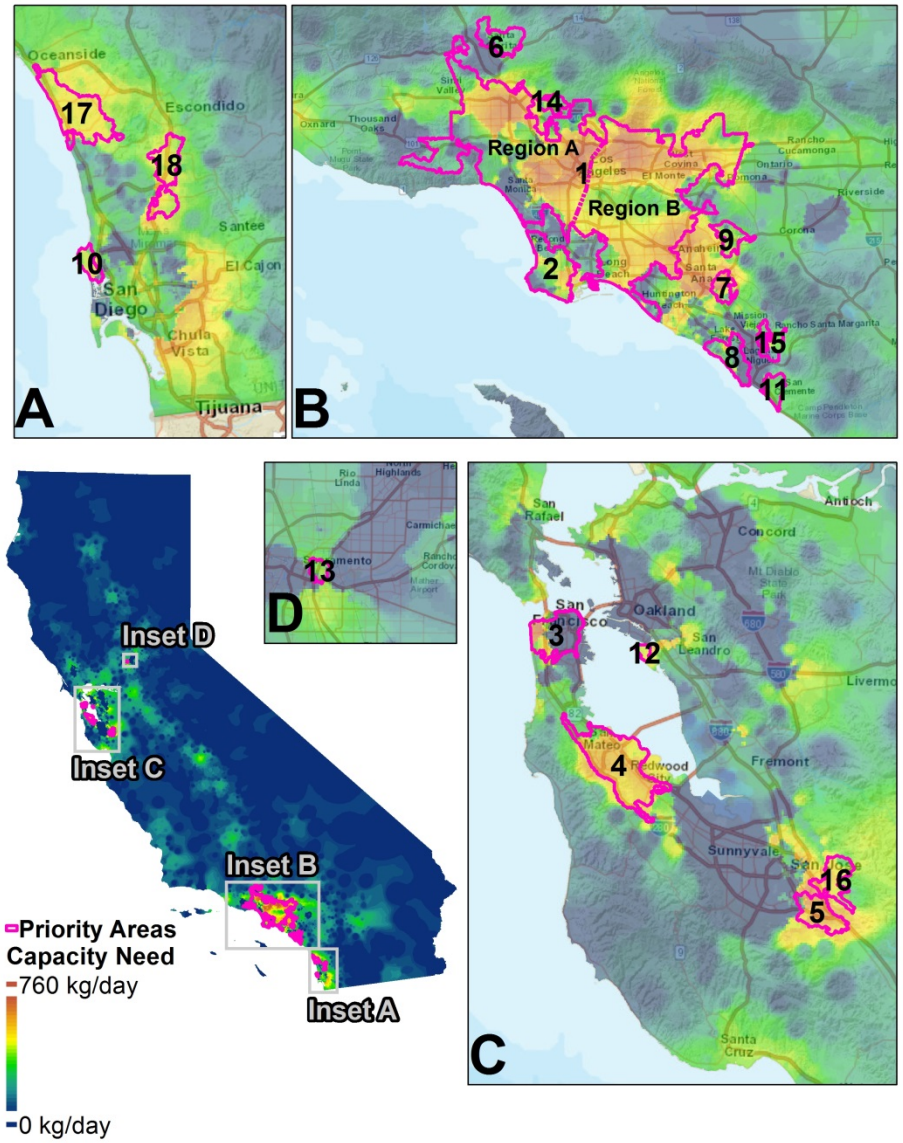




Using Local Capacity Estimation

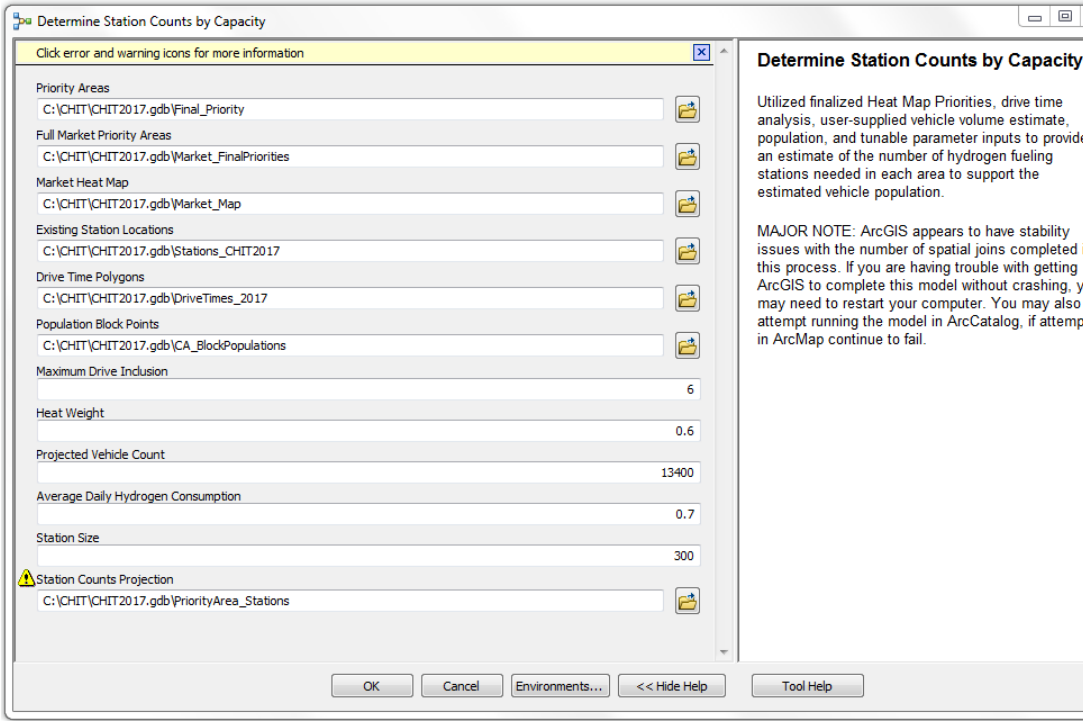
- Local Capacity Estimation Step 1 overwrites the Consumption_SeedPoints feature class with new calculated data
- CARB recommends maintaining a clean copy of Consumption_SeedPoints_Temp as a convenient backup of the initialized feature class so it can be used to re-initialize after previous evaluations
- Local Capacity Estimation Step 2 requires the modified Consumption_SeedPoints output of Step 1
- 15-minute drive time polygons and consumption seed points provided in CHIT2017 have synched data fields for matching
  - Necessary for processing steps to associate "captured" demand with each consumption seed point
  - CHIT Users' Guide v2 provides guidance for users to create their own files in case they wish to use their own set of consumption seed points
- See CHIT Users' Guide v2 for important notes on processing settings for stable execution

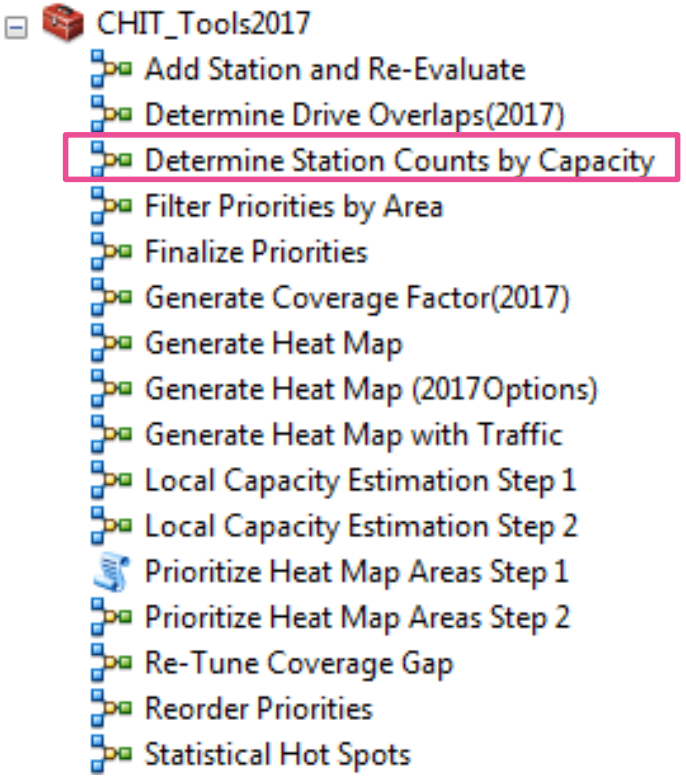
Localized Capacity Need in CHIT 2017



- Provides direct calculation of capacity metric as separate from coverage metric referenced in AB 8 and other efforts
- Coverage and capacity similar and related, but can be very different locally
- Spotty appearance (especially in low-need areas) by-product of interpolation method

A Note on Priority Area Capacity Needs



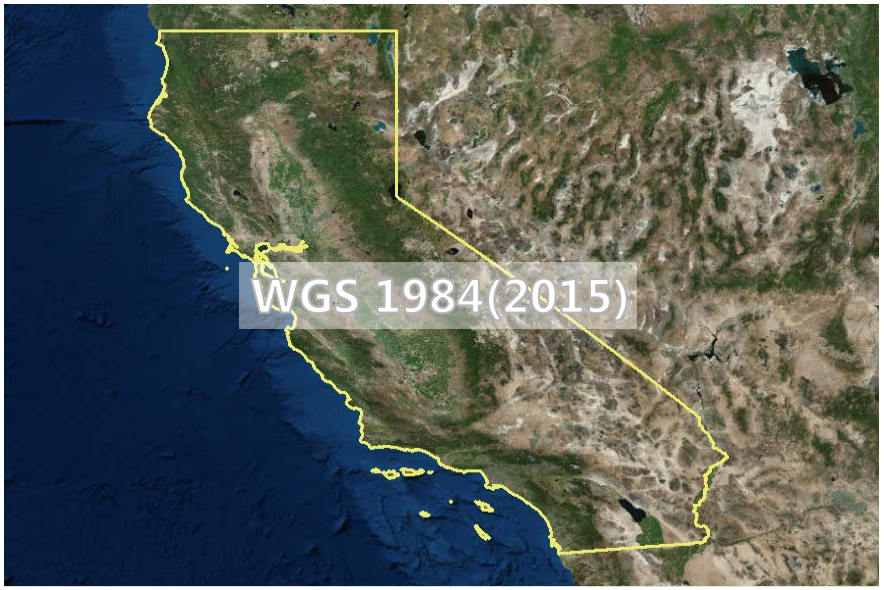


NOTES:

- CHIT 2015 Release included a tool for determining the number of stations (based on user-provided station capacity and FCEV deployment assumptions) needed in Priority Areas
- The tool's main purpose is to determine number of stations needed in each Priority Area
- The tool's math DOES preserve total capacity need for a given FCEV deployment volume
- An updated version of this tool is still available in CHIT 2017 Release
- The Priority Area needs and Local Capacity tools have similar characteristics but are fundamentally different in intended use and interpretation

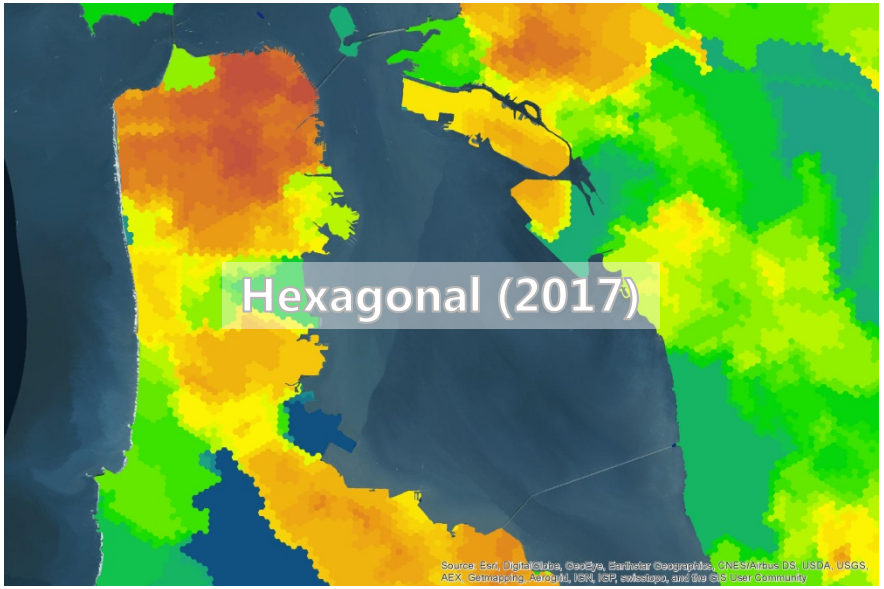
EVALUATION GRID UPDATE

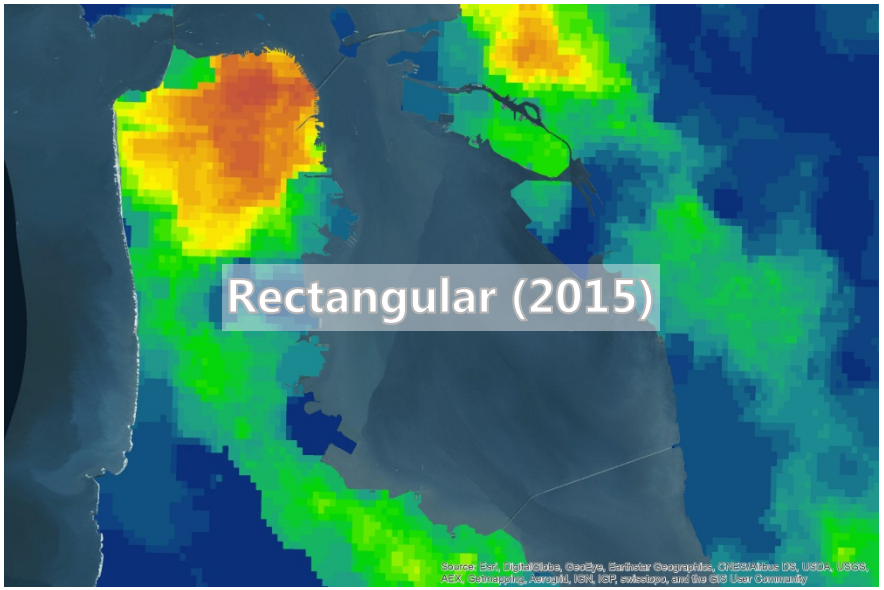
Standardized Coordinate System



- Part of CARB-wide effort to standardize GIS data products
- Agreed-upon agency-wide coordinate system is Projected State-Based NAD 1983 California Teale-Albers (CARB has implemented the 2011 update for CHIT 2017 Release)
- Effect should be transparent to majority of users
- ArcGIS has extensive routines and methods to automatically manage combining data sets with varying coordinate systems
- CHIT 2017 Release default data all provided in this coordinate system, but can still be used with data in other coordinate systems

Hexagonal Analysis Grid





- New analysis grid implemented in CHIT 2017 Release
- Analysis grid is basis of geometries used to aggregate spatial distribution of underlying data inputs
- Modern GIS pursuits and tools have recognized several benefits of a hexagonal grid compared to a rectangular grid (see CHIT Users Guide v2 for discussion)
- Hexagonal grids' largest disadvantage to a CHIT user is increased number of vertices, which translates to increased calculation load in GIS systems

DEMOGRAPHIC DATA UPDATES AND CVRP

CHIT Demographic Principles

- Principle #3: CHIT assesses only the first adopter market
- Principle #4: Identification of the FCEV owner market can be estimated by consideration of the relative distribution of multiple demographic indicators; the total fueling market potential can be estimated by consideration of both the owner market and commonly-traveled routes

- Demographic-based indicators used in CHIT:
  - Household income
  - Rates of graduate degree attainment
  - Past green vehicle adoption rates (PHEV/HEV)
  - Past luxury vehicle brand adoption rates

- Income, Education from US Census Bureau's American Community Survey. Updated to latest available for CHIT 2017.

- Vehicle adoption data from DMV historical records. Luxury vehicles updated to trends for last 5 years. Green vehicle data (PHEV rates in first adopter period) now completely specified in CHIT 2017.

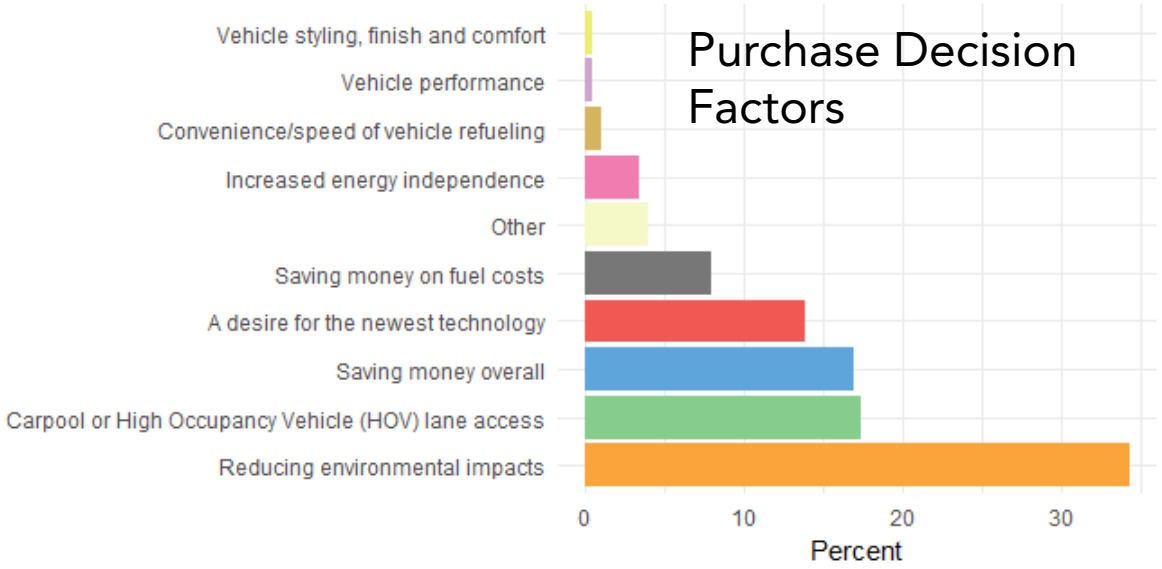
Motivation

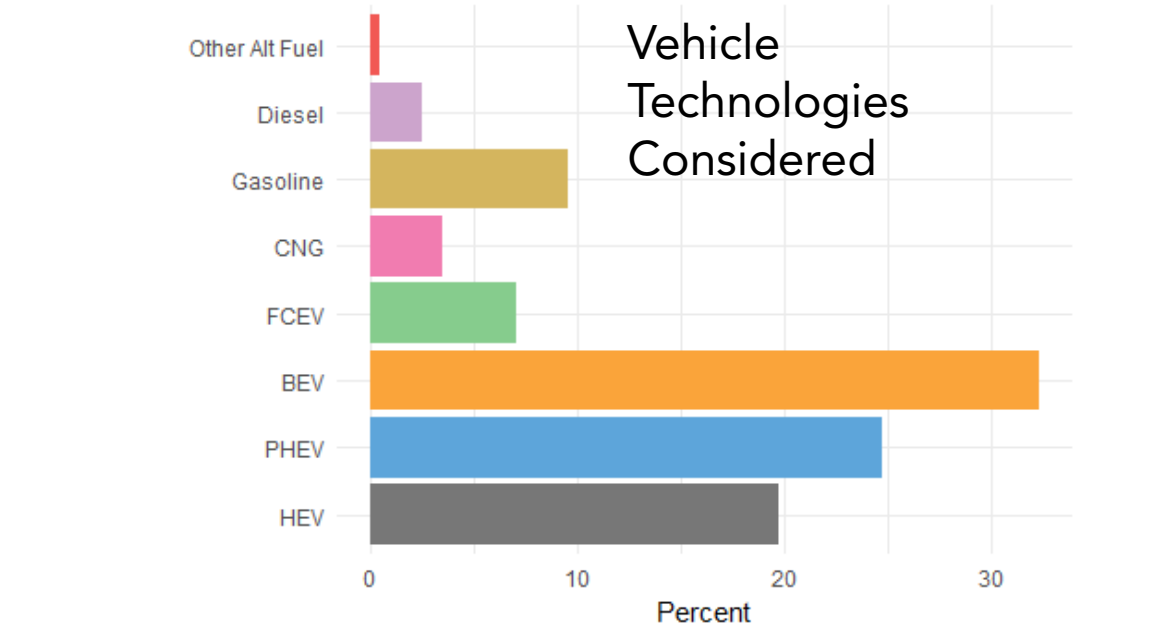
- Fundamental principles and selection of data inputs for market evaluation based on assumptions, expectations, and prior research of indicators for likelihood of FCEV adoption
  - Many of these indicators are more general for "green" or "new" technology adoption overall
  - California, among other jurisdictions worldwide, is one of the first places where factors indicating likelihood of adoption can be empirically evaluated

- The Clean Vehicle Rebate Project (CVRP) includes optional surveys for FCEV purchases to provide feedback to CARB
  - A purchase decision survey is currently the only active survey
  - Follow-on surveys are in development and will be offered for ongoing input from FCEV adopters

Purchase Motivations

- Reducing environmental impacts #1 purchase motivator
- FCEV chosen with significant amount of technology cross-shopping

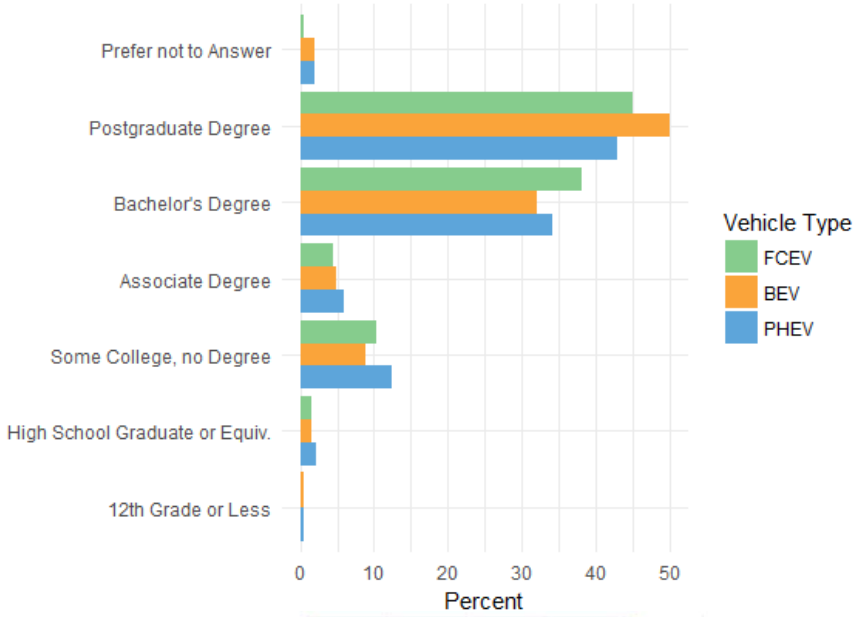




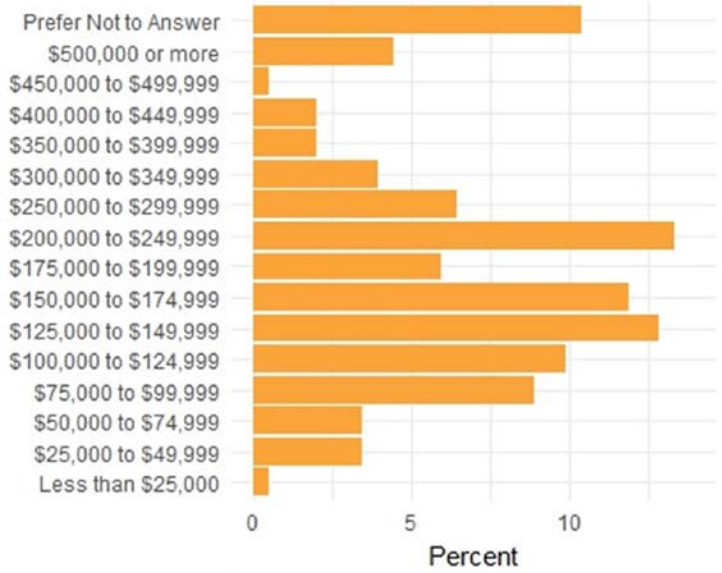
Demographics

- CHIT uses demographic indicators of income and education attainment
- Survey responses seem in line with educational factor use
- Income considered by CHIT may be higher than responses

FCEV Adopters Highest Deg Attained



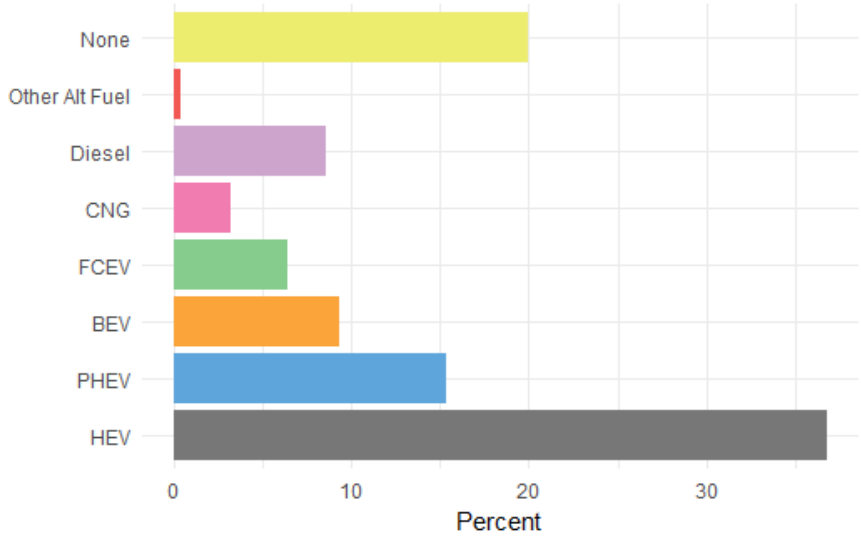
Distribution of FCEV Adopters Household Income



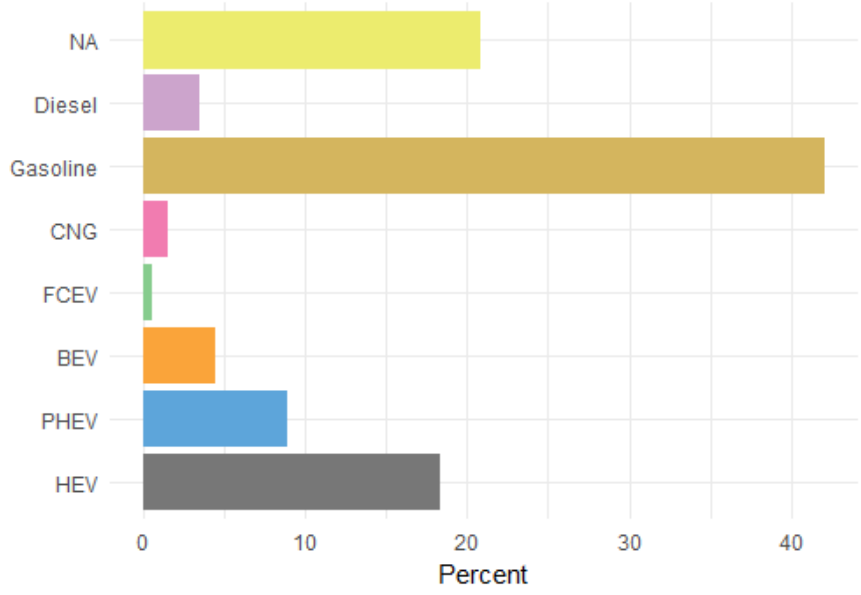
Past Vehicle Purchase Indicators

- Past green vehicle adoption used in CHIT as indicator for FCEV adoption
- Implemented as HEV/PHEV (not BEV)
- Survey data appear to support method

Past Alternative Fuel Vehicle Ownership

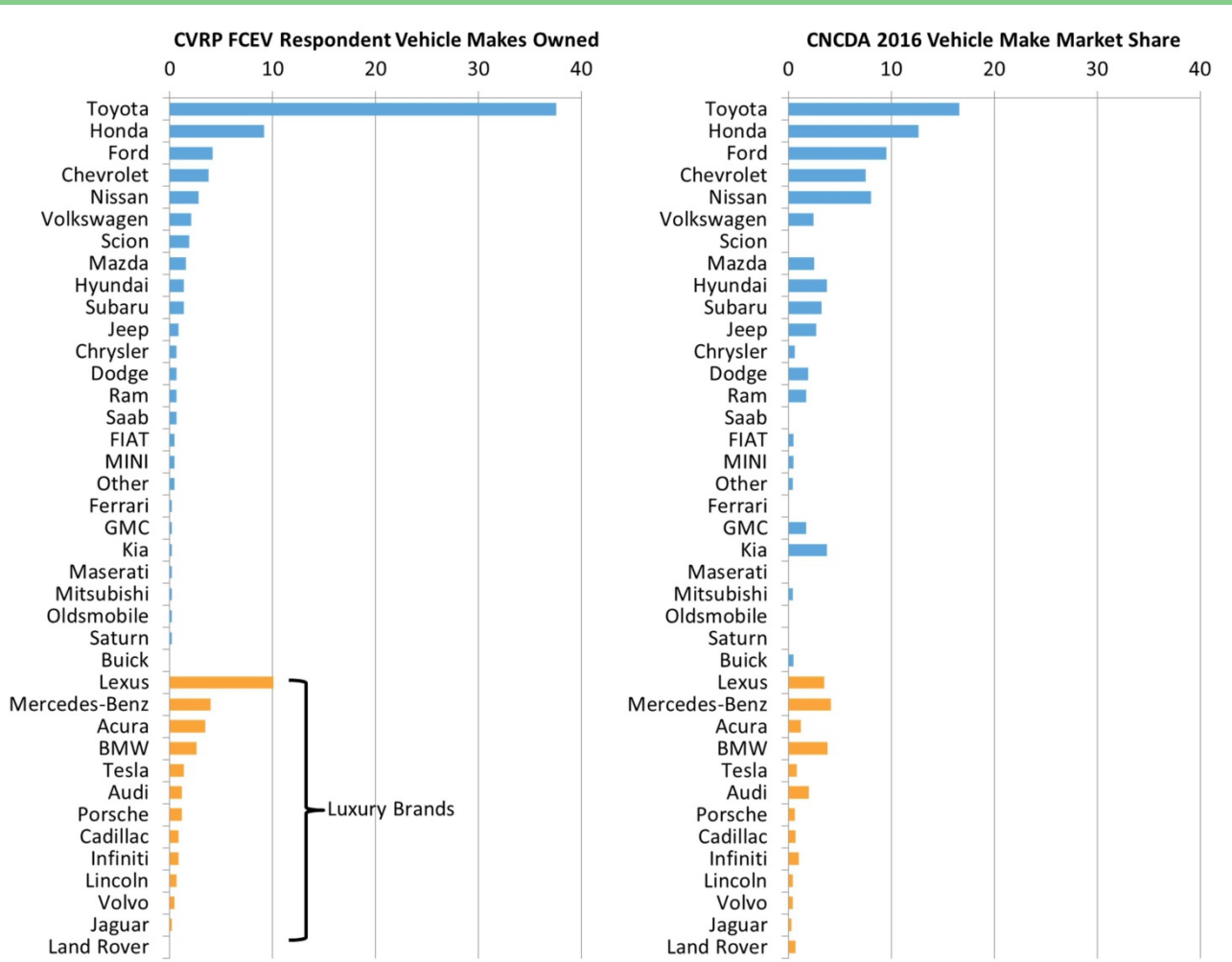


Technology of Vehicle Replaced



Past Vehicle Purchase Indicators

- Luxury vehicle branding previously cited as potential indicator for FCEV adoption
- May be slightly more affinity in FCEV adopters, but maker loyalty and differences in deployment plans may also play a role



Other vehicle makes owned by adopters vs. new car market

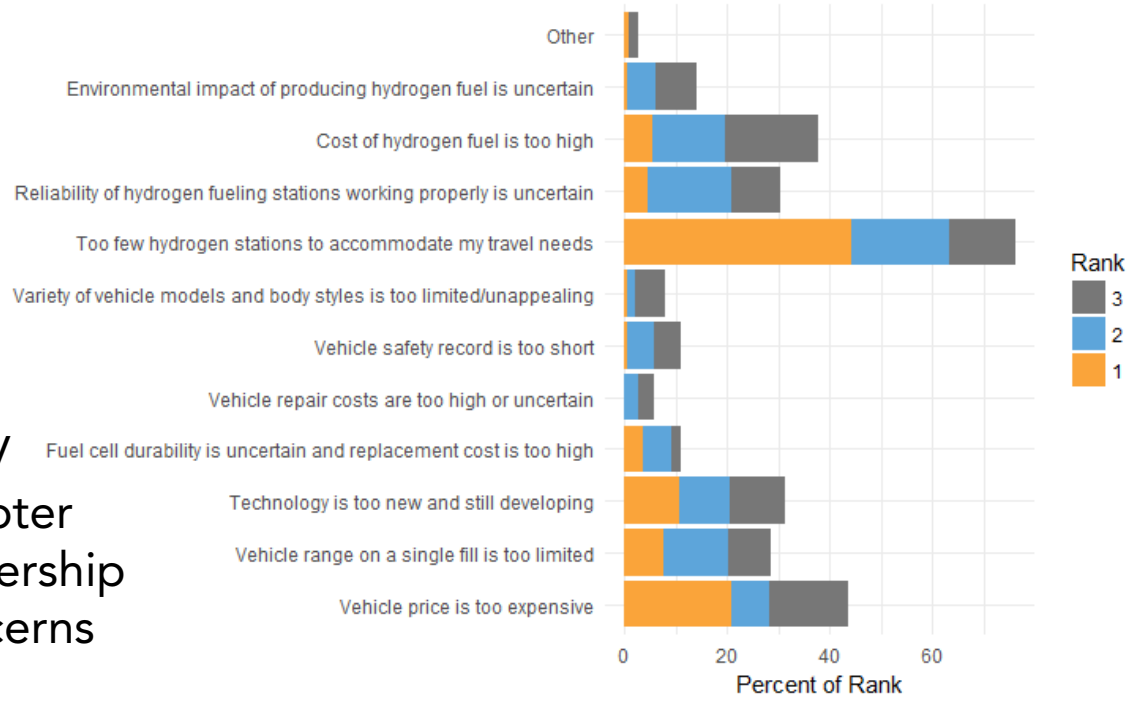
CHIT Coverage Principle

Principle #6: Coverage matches the market when it provides convenient fueling access near FCEV drivers' homes and/or within proximity to commonly-traveled routes

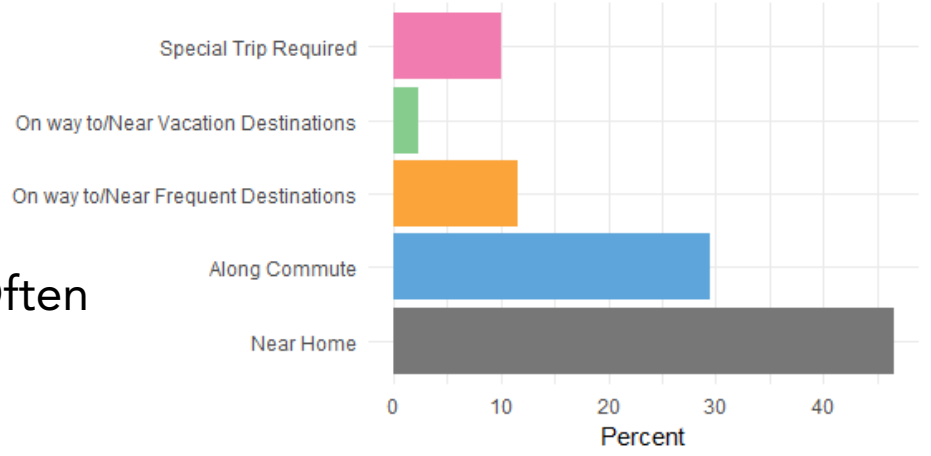
Importance of Station Locations

- Stations are early adopters' primary concern
- Price (vehicle and fuel) were second largest concern
- Drivers most often fueling near home

FCEV Adopter Ownership Concerns



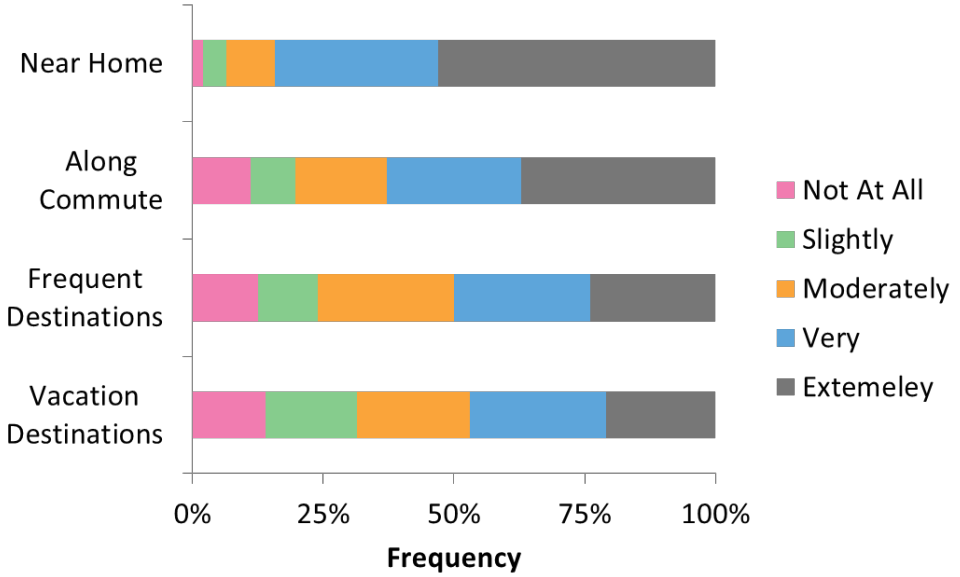
Location FCEV Drivers Most Often Currently Fuel



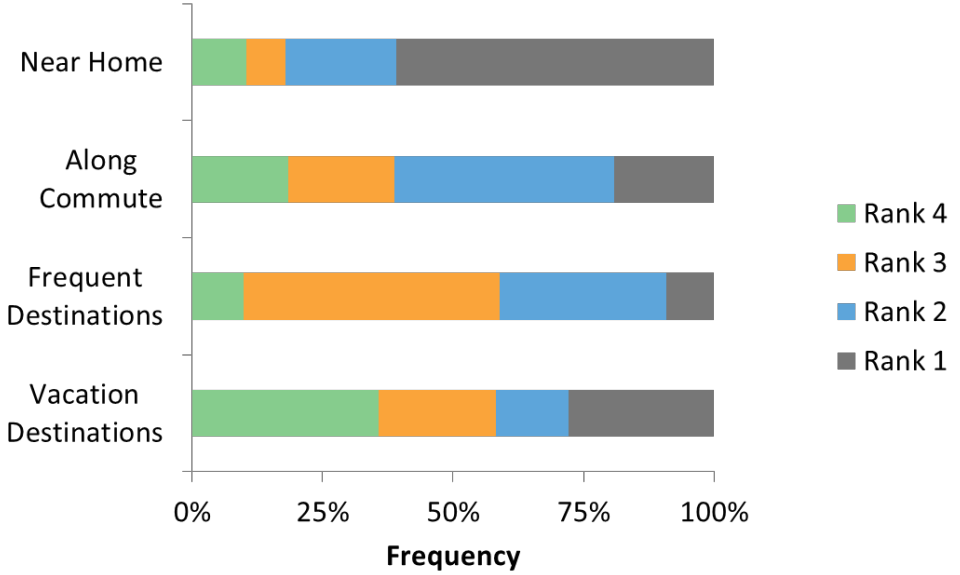
Importance of Station Locations

- Locations of stations affect the purchase decision based on their location relative to the FCEV adopter
- Additional near-home location most needed

Importance of Various Station Locations in Purchase Decision



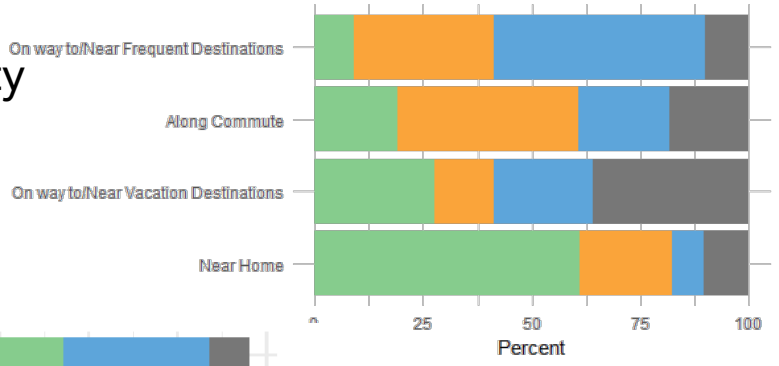
Importance of Additional Station Location to Allow Exclusive Use of FCEV for all Needs

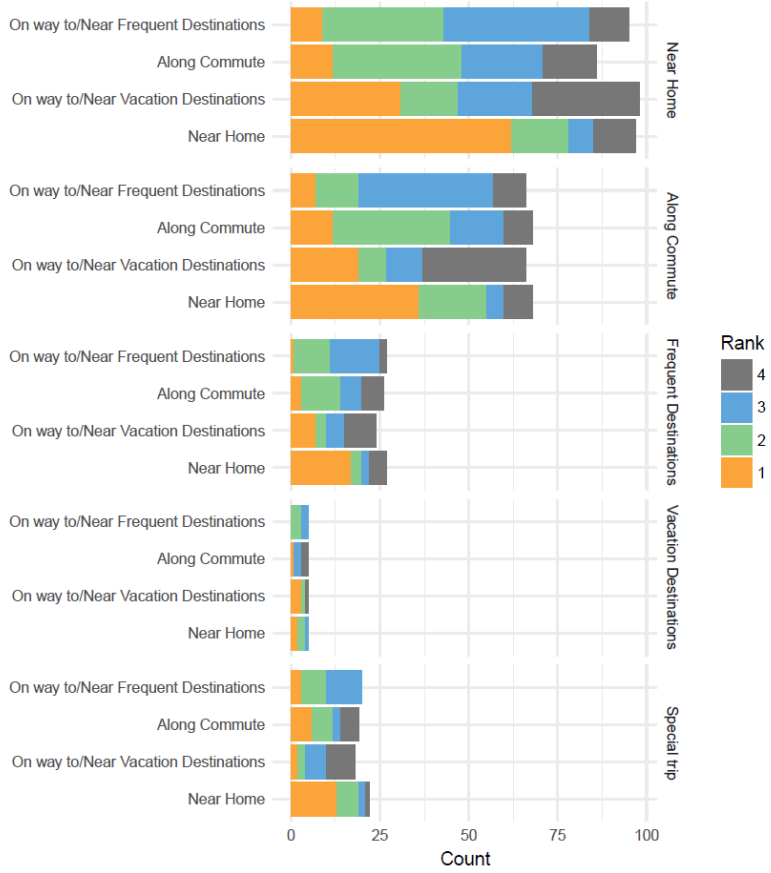


Desired Station Locations

- Additional stations near home are the most desired location overall and (mostly) regardless of the station location drivers currently use most often

Ranked Desirability of a New Station in Various Locations





Ranked Desirability of a New Station in Various Locations, Grouped by Location Currently Most Often Used

ONLINE VIEWER

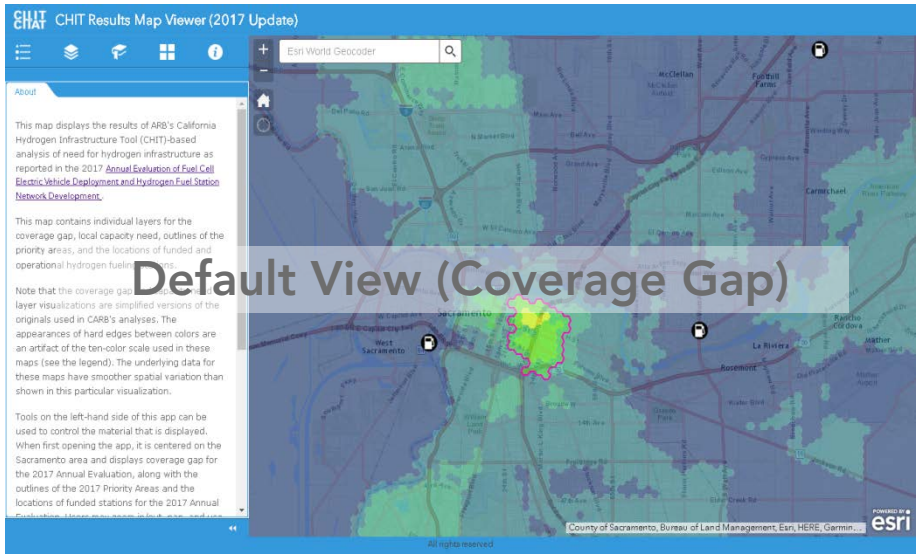
Updated Online Viewer for CHIT 2017 Release

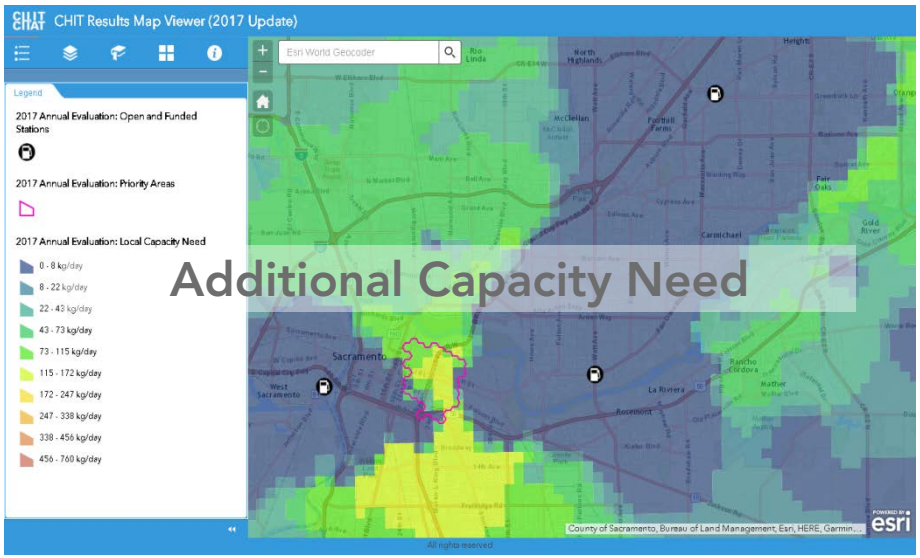
- Intended to allow interested parties without access to desktop ArcGIS (since it is not free software) to have access to the results of the CHIT analysis utilized in the 2017 Annual Evaluation

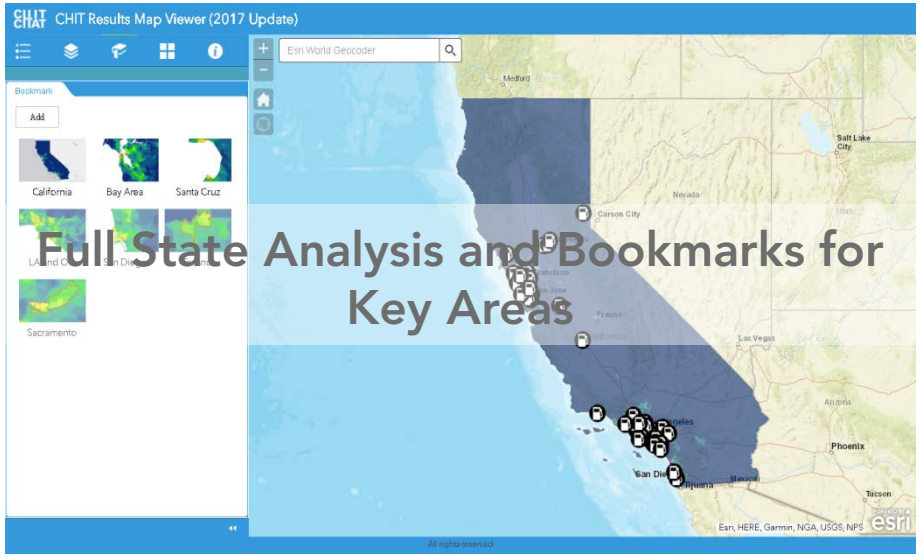
- Link provided on CARB's Hydrogen Fueling Infrastructure Assessments page: https://www.arb.ca.gov/msprog/zevprog/hydrogen/h2fueling.htm

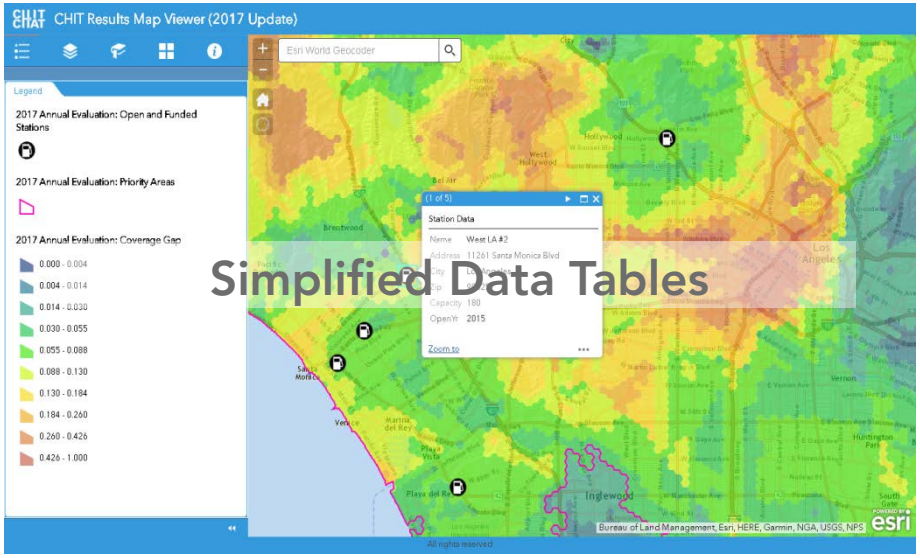
- Previously provided similar map viewer for CHIT 2015 Release results used in 2015 and 2016 Annual Evaluations and updated analysis used for GFO-15-605

Updated Online Viewer for CHIT 2017 Release









FUTURE IMPLEMENTATION

Ongoing Development Concepts

- Scenario analysis tool of station placement
  - Exploration of "what if" scenarios for numbers/locations of stations assuming various station technology development and vehicle rollout schedules
  - CARB is NOT developing this as a capability to determine specific optimized locations for station placement
  - Any analysis likely to be presented for discussion and aggregated regionally
- Addition of a redundancy factor to increase CHIT coverage gap evaluation tendency to cluster stations
- Implementation of station availability data (such as through SOSS) to scale coverage provided by stations
  - Proprietary station operational data concerns need to be recognized
- Addition of station throughput data (such as through NREL data reporting) as an additional observational demand input
  - Proprietary station operational data concerns need to be recognized

ACCESS TO CHIT DATA AND TOOLS

CHIT Desktop Tool available at (2017 and 2015 Releases both posted):
https://www.arb.ca.gov/msprog/zevprog/hydrogen/h2fueling.htm

CHIT 2017 Release Online Map Viewer:
http://californiaarb.maps.arcgis.com/apps/webappviewer/index.html?id=99be905d3127405e81851fd60b19cda2

CHIT 2015 Release and GFO-15-605 Online Map Viewer still Available:
http://californiaarb.maps.arcgis.com/apps/webappviewer/index.html?id=f2bc784715984f3cb2905dbc4a0391b6

OPEN DISCUSSION

For questions or comments, contact:
Andrew Martinez
(916) 322-8449
andrew.martinez@arb.ca.gov

Coverage, Capacity, and Market Viability under GFO-15-605

Jane Berner

Hydrogen Unit
Fuels and Transportation Division
California Energy Commission

November 14, 2017

Objectives

- Review the GFO-15-605 evaluation criteria
- Focus on the "Coverage, Capacity, and Market Viability" evaluation criterion
  - California Hydrogen Infrastructure Tool (CHIT) components
  - Non-CHIT components
- Review each component
  - What types of information could have been provided?
  - Comments and questions

Upcoming Energy Commission Staff Workshops on Hydrogen Station Network Future Approaches

- November 30:
  Hydrogen Refueling Infrastructure Alternative Funding Mechanisms
- December 4:
  Hydrogen Refueling Station Technical Requirements
- December 14:
  Evaluation Criteria for Hydrogen Refueling Station Applications, Critical Milestones, and Data Collection

Docket Information

- http://www.energy.ca.gov/altfuels/2017-HYD-02/
- On this site
  - Relevant workshops, notices, and documents
  - Submit e-comments
  - Contact information
  - Subscribe to Alternative Fuels List Serve

GFO-15-605 Evaluation Criteria

Evaluation Criteria	Possible Points
Qualifications of the Applicant/Project Team	60
Coverage, Capacity, and Market Viability	100
Safety Planning	40
Project Readiness	40
Station Operation and Maintenance	40
Project Budget	25
Financial Plan	15
Hydrogen Refueling Station Performance	60
Economic and Social Benefits	20
Innovation	20
Renewable Hydrogen Content	30
Renewable Hydrogen from Direct Sources	30
Sustainability and Environmental Impacts	20
Total Points	500

GFO-15-605 Scoring Scale Summary

From GFO-15-605, Table 8

% of Possible Points	Interpretation
0%	Not Responsive
10 – 30%	Minimally Responsive
40 – 60%	Inadequate
70%	Adequate
80%	Good
90%	Excellent
100%	Exceptional

GFO-15-605 Scoring Scale

% of Possible Points	Interpretation	Explanation of Percentage Points
0%	Not Responsive	Response does not include or fails to address the requirements being scored. The omission(s), flaw(s), or defect(s) are significant and unacceptable.
10-30%	Minimally Responsive	Response minimally addresses the requirements being scored. The omission(s), flaw(s), or defect(s) are significant and unacceptable.
40-60%	Inadequate	Response addresses the requirements being scored, but there are one or more omissions, flaws, or defects or the requirements are addressed in such a limited way that it results in a low degree of confidence in the proposed solution.
70%	Adequate	Response adequately addresses the requirements being scored. Any omission(s), flaw(s), or defect(s) are inconsequential and acceptable.

From GFO-15-605, Table 8

Continued on next slide

GFO-15-605 Scoring Scale, Continued

% of Possible Points	Interpretation	Explanation of Percentage Points
80%	Good	Response fully addresses the requirements being scored with a good degree of confidence in the Applicant's response or proposed solution. No identified omission(s), flaw(s), or defect(s). Any identified weaknesses are minimal, inconsequential, and acceptable.
90%	Excellent	Response fully addresses the requirements being scored with a high degree of confidence in the Applicant's response or proposed solution. Applicant offers one or more enhancing features, methods or approaches exceeding basic expectations.
100%	Exceptional	All requirements are addressed with the highest degree of confidence in the Applicant's response or proposed solution. The response exceeds the requirements in providing multiple enhancing features, a creative approach, or an exceptional solution.

From GFO-15-605, Table 8

Application Content

From GFO-15-605, Section IX (F)(4)(g)

"Applicants should address each Evaluation Criterion in this solicitation (including all sub-bullets under each criterion) providing sufficient, unambiguous detail so that the Energy Commission Evaluation Team will be able to evaluate the application.

Applicants are highly encouraged to use the exact titles from the Evaluation Criteria as the heading for each response.

If an Evaluation Criterion does not apply to the proposed project, Applicants should briefly describe why the criterion does not apply."

Coverage, Capacity, and Market Viability Evaluation Criterion

- CHIT coverage
- CHIT capacity
- Projected vehicle demand
- Redundancy and back-up
- Fleets
- Peak fueling
- Average number of fills
- Proximity to facilities
- Complements existing and planned stations

Coverage, Capacity, and Market Viability (Main Station Competition)

From GFO-15-605, Table 9

"Applications will be evaluated on the degree to which:

- The proposed station location results in a high CHIT Station Coverage Value.
- The proposed station capacity results in a high CHIT Station Capacity Value.
- The proposed station provides refueling service that meets the hydrogen refueling needs for the projected vehicle demand (light duty vehicle traffic count and patterns).
- The proposed station provides redundancy and back-up in a location needing fueling capacity."

Continued on next slide

Coverage, Capacity, and Market Viability (Main Station Competition)

Continued from previous slide

"Applications will be evaluated on the degree to which:

- The proposed station provides refueling service for local fleets, as practicable.
- The proposed station provides refueling service that is available during peak fueling periods for light duty vehicles passing the station (daily, weekly, or during other time periods) and the peak fueling periods for the location do not conflict with timeframes allowed by local ordinances.
- The proposed station meets the needs of a higher average number of fills over a 1- and 12-hour period."

Continued on next slide

Coverage, Capacity, and Market Viability (Main Station Competition)

Continued from previous slide

"Applications will be evaluated on the degree to which:

- The proposed station provides refueling service for vehicles tested and deployed at automotive parts assembly, testing, distribution, and demonstration facilities.
- The proposed station's refueling service complements the coverage and capacity of the network of existing and planned hydrogen refueling stations in Table 1 and any other new stations proposed for funding by the Applicant under this solicitation."

First and Second Bullet Points

"The proposed station location results in a high CHIT Station Coverage Value."

"The proposed station capacity results in a high CHIT Station Capacity Value."

- Applicants provided these two values in their applications
- CARB confirmed the values with the Energy Commission Evaluation Team
- The Evaluation Team considered the CHIT values qualitatively and independently
- CARB recalculated CHIT values after each station was selected

Classification of Data

- For transparency and completeness, CHIT results have been provided to the public and GFO applicants with relatively high precision
  - Online Map: Range from 0-1, with precision to 0.0001
  - Desktop Tool: Coverage Gap and other data provided with precision to 0.000001
- Significant differences in values do not occur at such high precision
- CHIT's hot spot analysis, priority area determinations, and visualization in the online map seek to identify meaningful differences in values
- Use of CHIT in the GFO process was similarly informed, using the Natural Breaks method to determine meaningful differences between CHIT values
- Natural Breaks is a statistics-based method that minimizes the total variation within ranges. The effect is to identify groups of statistically similar values. In practice, groups are often separated by gaps in data values.

Classification of Data

- During scoring rounds of GFO 15-605, the Natural Breaks classification system was as an information resource by the Evaluation Team when they made qualitative assessments of CHIT values.

- The information considered by the team included:
  - Ranges of CHIT values statistically similar to each other
  - The proportion of CHIT values in each range
  - CHIT ranges and proportions evaluated on the basis of all evaluation cells across the state

- This evaluation was repeated after every "CHIT round"

- CARB and the Energy Commission collaborated closely throughout all CHIT Rounds and evaluations

Classification of Data

- After every proposed station award was selected, the entire distribution of coverage gap scores, classes, and size of classes were re-evaluated to reflect the changing interpretation of given Location Values

- For example, a Location Value of 0.311 may have been more rare and in a higher-ranked group after 12 rounds of awards than prior to any award selections

- In early rounds, a value of 0.311 may have been statistically similar to all values 0.2-0.4. After several awards, the distribution may have shifted, such that 0.311 was similar to values 0.282-0.333.

- These data were considered each round by all scorers to adjust their interpretation of Location Value scores

CHIT and Market Viability

From GFO-15-605, Section IV (C)

"The Energy Commission Evaluation Team will score the application using a combination of the CHIT Station Coverage Value, the CHIT Station Capacity Value, and the market viability as part of one Evaluation Criterion 'Coverage, Capacity, and Market Viability.'

Proposed locations that have low CHIT Station Coverage and CHIT Station Capacity Values, according to CHIT, have the opportunity to document, demonstrate, and bolster the CHIT Station Coverage and CHIT Station Capacity Values with the market viability of a proposed station and potentially be successful under this solicitation in accordance with the Evaluation Criteria."

Third Bullet Point

"The proposed station provides refueling service that meets the hydrogen refueling needs for the projected vehicle demand (light duty vehicle traffic count and patterns)."

- Possible responses
  - Fuel cell electric vehicle projections from CARB's AB 8 Annual Evaluation
  - Proximity and traffic flow to freeways, major streets
  - How serves origins and destinations
  - Consistency with regional transportation plan, general plan, alternative fuel readiness plan
  - Characteristics of local residential area, employment centers
  - Applicant's own observations about market potential

Third Bullet Point, Continued

"The proposed station provides refueling service that meets the hydrogen refueling needs for the projected vehicle demand (light duty vehicle traffic count and patterns)."

- Possible responses
  - Information from:
    - » Auto manufacturers or dealerships
    - » Location owner/operator
    - » Local governments
    - » FCEV drivers or prospective drivers

Fourth Bullet Point

"The proposed station provides redundancy and back-up in a location needing fueling capacity."

- Possible responses
  - Proximity to the nearest funded stations (open or planned)
  - Usage of those nearest stations
  - Is the proposed station near another station you are proposing? How do they support each other?
  - Is the station a redundant system?

Fifth Bullet Point

"The proposed station provides refueling service for local fleets, as practicable."

- Possible responses
  - List of identified local fleets and their potential refueling needs
    - Number of FCEVs
    - Estimated date needed
    - Time of day of refueling
  - Fleets are not part of the applicant's business model
    - Reasons why

Sixth Bullet Point

"The proposed station provides refueling service that is available during peak fueling periods for light duty vehicles passing the station (daily, weekly, or during other time periods) and the peak fueling periods for the location do not conflict with timeframes allowed by local ordinances."

- Possible responses
  - How the station meets or exceeds the minimum technical requirement for peak fueling capacity
  - Fuel sales in the local area (gasoline and hydrogen)
  - Hours of operation allowed by the local jurisdiction

Seventh Bullet Point

"The proposed station meets the needs of a higher average number of fills over a 1- and 12-hour period."

- Possible responses
  - How the station meets or exceeds the minimum technical requirements for daily fueling capacity and peak fueling capacity
  - Site design features (space to increase capacity)
  - Station design features (multiple fueling positions; compression, storage and dispensing systems)
  - Alignment of station design with anticipated demand

Eighth Bullet Point

"The proposed station provides refueling service for vehicles tested and deployed at automotive parts assembly, testing, distribution, and demonstration facilities."

- Possible responses
  - Partnerships the applicant has identified
    - Business agreement(s)
    - How the agreement(s) will enhance station viability
  - These types of facilities are not part of the applicant's business model
    - Reasons why
    - Other customer bases

Ninth Bullet Point

"The proposed station's refueling service complements the coverage and capacity of the network of existing and planned hydrogen refueling stations in Table 1 and any other new stations proposed for funding by the Applicant under this solicitation."

- Possible responses
  - How the proposed station location responds to the AB 8 reports' (CARB's Annual Evaluation or the Joint Report) findings related to coverage and capacity needs of the station network
  - How the proposed station location supports the needs identified through discussions with auto manufacturers, local stakeholders, and based on applicant's own analyses

Coverage, Capacity, and Market Viability Sub-Bullets

- Any comments or questions about them?
- Anything you like or dislike about them?
- In the future
  - How should CHIT be used?
  - What market viability factors should be included or excluded?
  - Why?

General Discussion

Questions

Comments

Suggestions