ARB VISION 2.0 OVERVIEW

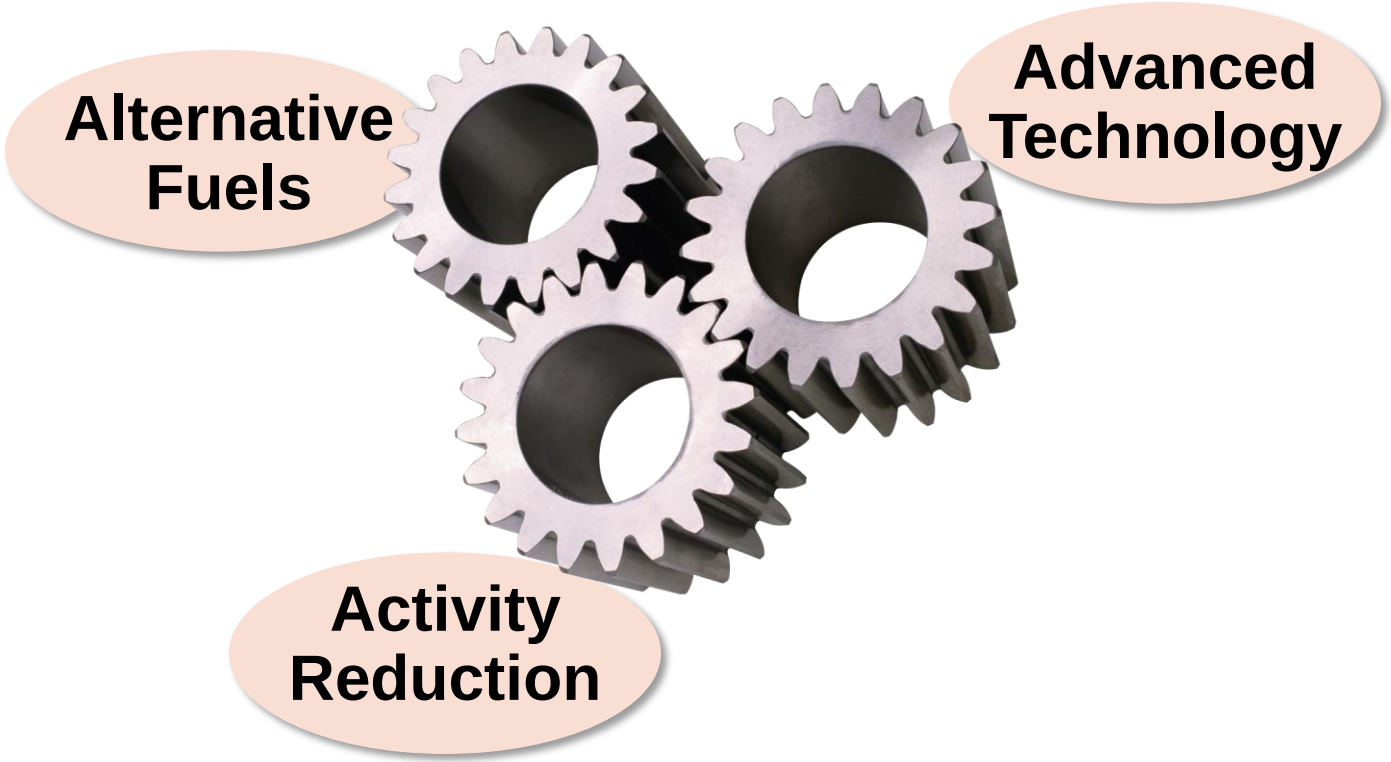
PUBLIC WORKSHOP STAFF PRESENTATION

MARCH 16, 2015

WORKSHOP AGENDA

- Vision program goals & plans
- Vision 2.0 model structure
- Developing scenarios
- Description of mobile sector modules
- Description of energy module & emission factors
- Next steps

MISSION: REDUCING EMISSIONS IN TRANSPORTATION "SYSTEM"

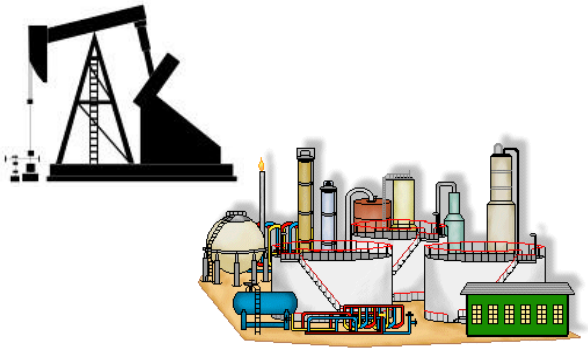


GOAL OF SCENARIO PLANNING

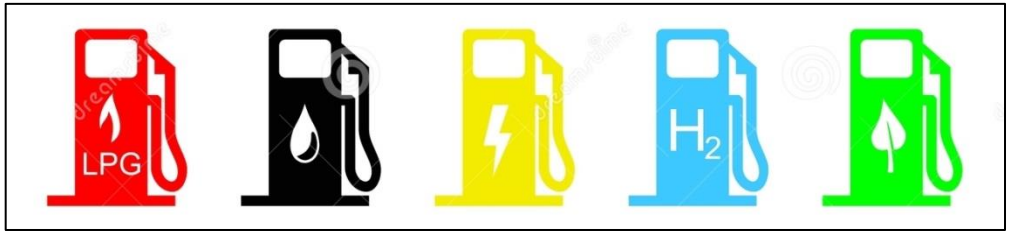
- U.S. DOE Scenario Planning definition
  - Identifying the range of possibilities of trends & policies
  - Developing a shared understanding of a problem

- ARB and State Agency Goals
  - Identify emissions benefits from existing programs, towards reaching emissions targets
  - Capture interactions of full transportation **system**
  - Explore hypothetical strategies to meet emission target
    - *Provide options for policymakers to consider*

SCENARIOS CAPTURE FULL TRANSPORTATION SYSTEM



ENERGY



DEMAND

VALUE OF VISION SCENARIOS FOR POLICYMAKERS

- Regulatory measures
  - Identify vehicle and fuel coordinated strategies
  - Inform scale of necessary emission reductions
- Public incentives and investments
  - Identify strategic areas with long-term emission benefits; informs spending priorities
- Local and regional planning
  - Highlight types of alternative fuels needed by sector (infrastructure planning)
  - Highlight fuel production and delivery transformation

VISION SCENARIO PLANS: INFORMING ARB PROGRAMS

- 2016 SIP for 75 ppb 8 hr ozone standard
- Governor's climate and petroleum targets
- Mobile sector policies for NOx & GHG reductions
  - Heavy duty vehicle & off-road policies
  - Light duty vehicle LEV/ZEV Rules
- Sustainable Freight
- Scoping Plan Updates
- Caltrans CTP 2040

KEY TRANSPORTATION QUESTIONS TO ADDRESS EMISSIONS GOALS

Systems

- How do strategies cut across climate, criteria, and community health goals?
- What are strategies for reaching 2032 NOx, 2050 GHG goals?

Mobile Technology

- What are benefits of potential HDV & Off-Rd NOx policies?
- What scale of electrification in varying mobile sectors?

Fuels

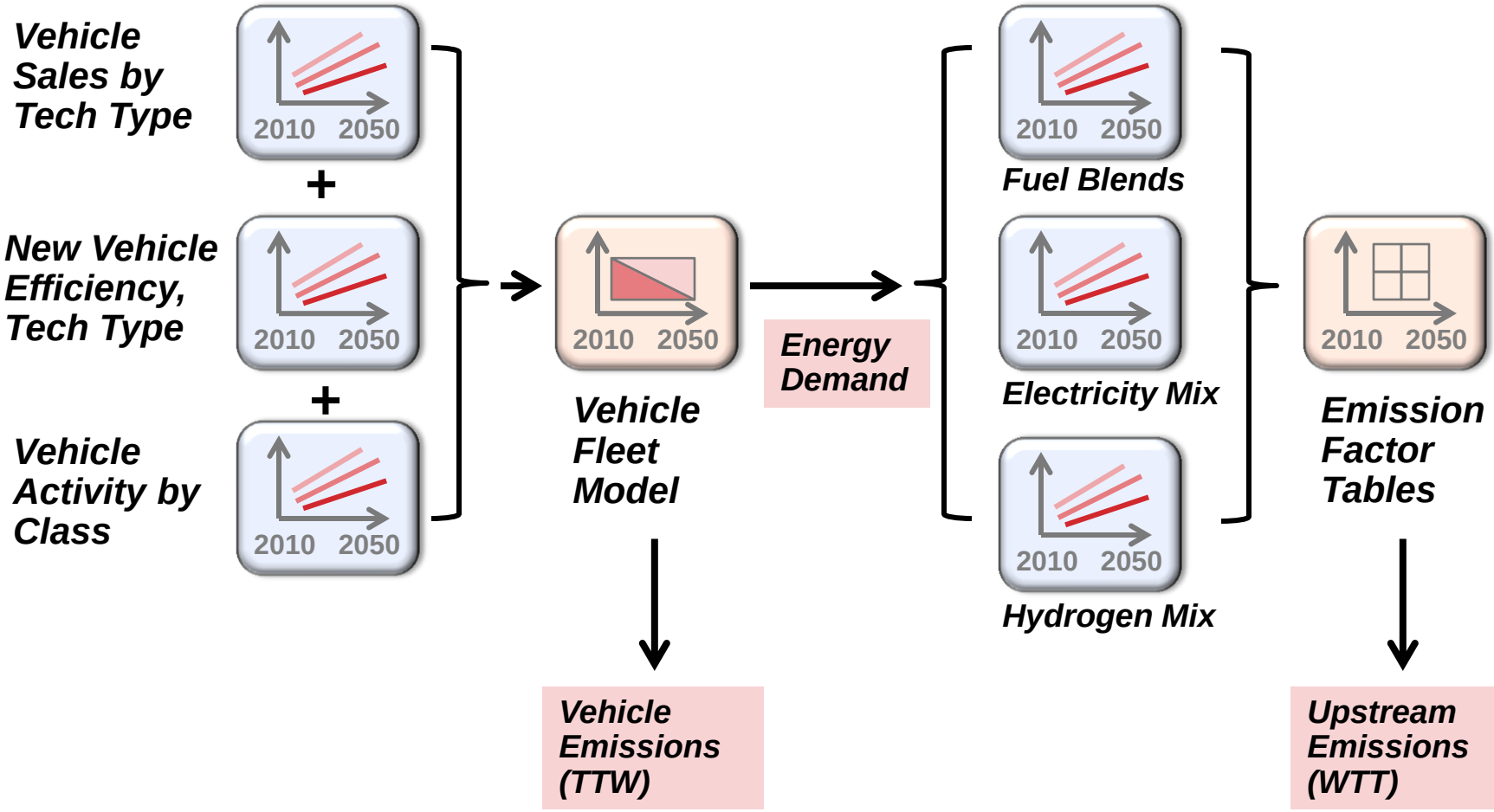
- What scale of biofuel carbon intensity reduction is needed?

Activity Change

- What are the benefits of VMT reductions beyond SB 375?
- Are there efficiency improvements across freight modes?

MODEL STRUCTURE

SCENARIO TOOL FRAMEWORK



SECTORS IN VISION 2.0

Mobile Sectors Included

- Passenger vehicles
- Heavy-duty vehicles
- Rail (freight, passenger)
- Aviation
- Ocean going vessels (in-development)
- Cargo handling equipment
- Commercial harbor craft
- Construction equipment
- Other off-road vehicles

Stationary Sectors Included

- Industry, including fuel production activities
- Residential and commercial buildings
- Non-energy sectors: waste, agriculture, etc (in development)

UNIQUE VALUE OF TRANSPORTATION MODELS (1)

- Rigorous match to existing ARB policies & inventories
  - Captures nuances of regulations (e.g. ACC, LCFS), including regulatory metrics, credits, compliance projections, etc
  - Captures newest official emissions inventories
- Detailed mobile sector disaggregation by vehicle class
  - To inform specific mobile sector rules, plans
  - Allows detailed assumptions of technology by vehicle class

UNIQUE VALUE OF TRANSPORTATION MODELS (2)

- Incorporates multiple pollutants
  - CO2e, NOx, PM2.5, VOC/ROG
  - Well-to-tank (WTT) criteria emission factors for CA facilities (in-state controlled stationary sources)
  - AB 32 GHG emissions accounting boundary (portions of upstream fuel production occurring in-state)

- Detailed spatial resolution; Data for ozone simulations
  - State, air basins, counties, census block

DEVELOPING SCENARIOS

DEVELOPING SCENARIOS: SCENARIO FRAMEWORK

- Modeled years: 2010 – 2050
- Multi-sector tradeoffs
  - Study buildings and non-energy sectors to identify their potential for emission reductions
  - Which strategies are appropriate for specific veh sectors
- Scenarios
  - Baseline – all existing major policies and rules
  - Open-ended – extensions of existing policies
  - Top-down – aggressive tech, fuels, activity assumptions
  - Top-down – accelerated strategies

DEVELOPING SCENARIOS: IDENTIFYING INPUTS

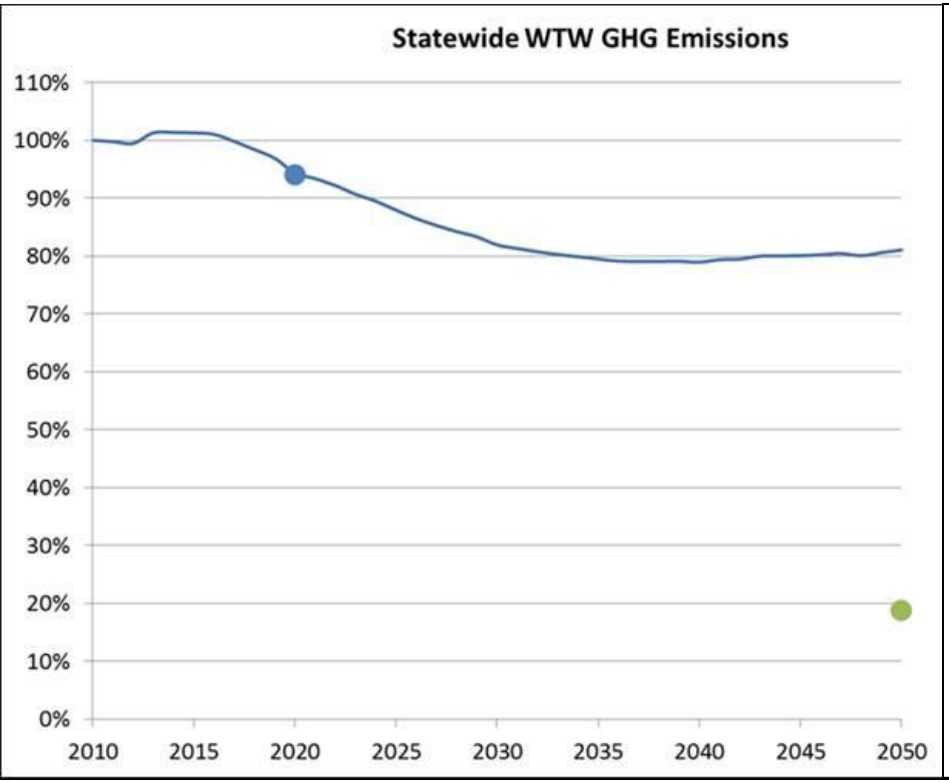
- Leverage ARB Technology Assessment
  - Mobile sector technology readiness, market
  - Other agency assessments: CEC, U.S. DOE, U.S. EPA
- External research and data
  - Academia, National Academies, CCST, National Labs
  - Industry data where publicly available
- Evaluating strategy aggressiveness across sectors

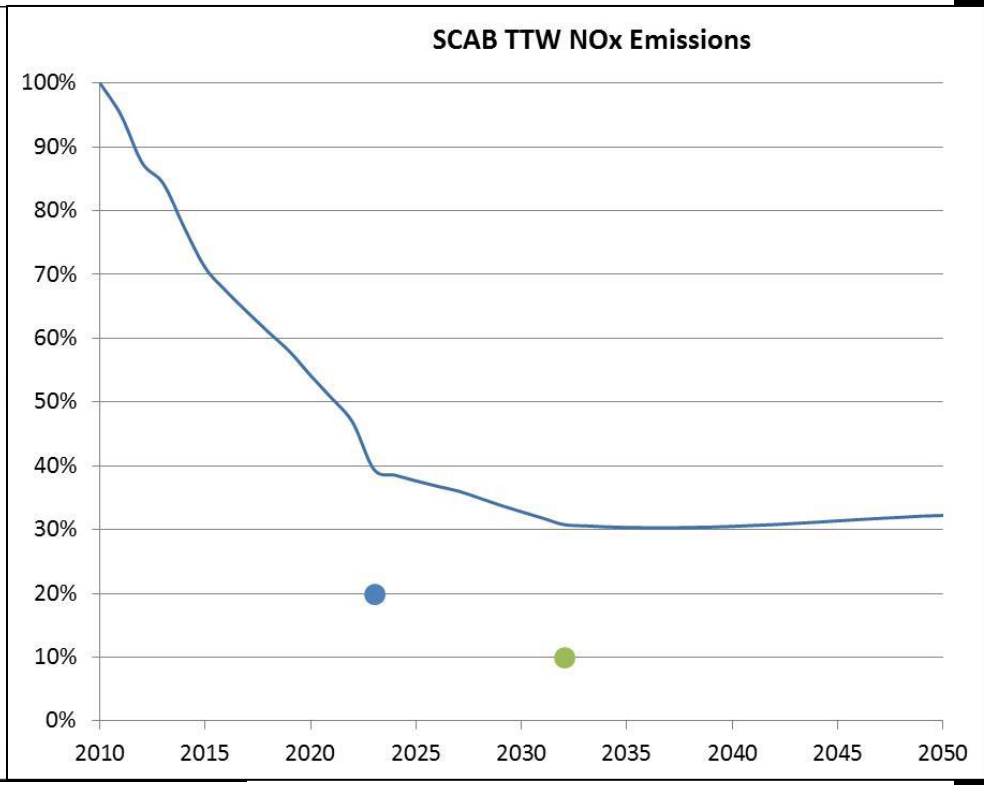
BASELINE SCENARIO: MAJOR POLICIES INCORPORATED

- Mobile:
  - EMFAC 2014 inventory updates (LDV & HDV)
  - LDV: LEV/ZEV (Advanced Clean Cars) & SB 375
  - HDV: Phase 1 GHG, 2010 NOx Std and Truck/Bus rule
  - Rail: Updated rail inventory and 1998 Rail MOU
- Fuels:
  - LCFS: Assumes 2020 ARB compliance scenario
  - Grid: RPS 33% renewables by 2020
  - Hydrogen: SB 1505 33% renewables, expected by 2020
  - Biomethane: Landfill methane & waste diversion for biogas

RESULTS: *BASELINE*

Sectors included are transportation, fuel production, and buildings





● = AB 32 Requirement
● = CA Executive Order 2050 climate target

● = SCAB 2023 NOx target, 80% below 2010
● = SCAB 2032 NOx target, 90% below 2010

Note: WTW = well-to-wheel; TTW = tank-to-wheel (vehicle emissions); SCAB = South Coast Air Basin

DESCRIPTION OF SECTOR MODULES

PASSENGER VEHICLES

GOALS

- For calendar years 2010-2050, overlay existing passenger vehicle inventory with any mix of:
  - Technology (defined by the user, not the model)
  - Population or VMT changes
- Maintain as much specificity as possible
- Flexibility to run baseline, incentive, turnover scenarios with any population, VMT, or technologies

DATA SOURCES

- EMFAC2014 – July 2014 draft version
  - Base Populations
  - Emission Rates/Fuel Consumption Rates
  - Accrual and Trip Rates
  - Sales and Attrition Rates
  - Growth Rates

- EMFAC2014 reflects all adopted policies for passenger vehicles such as Advanced Clean Cars (ACC)

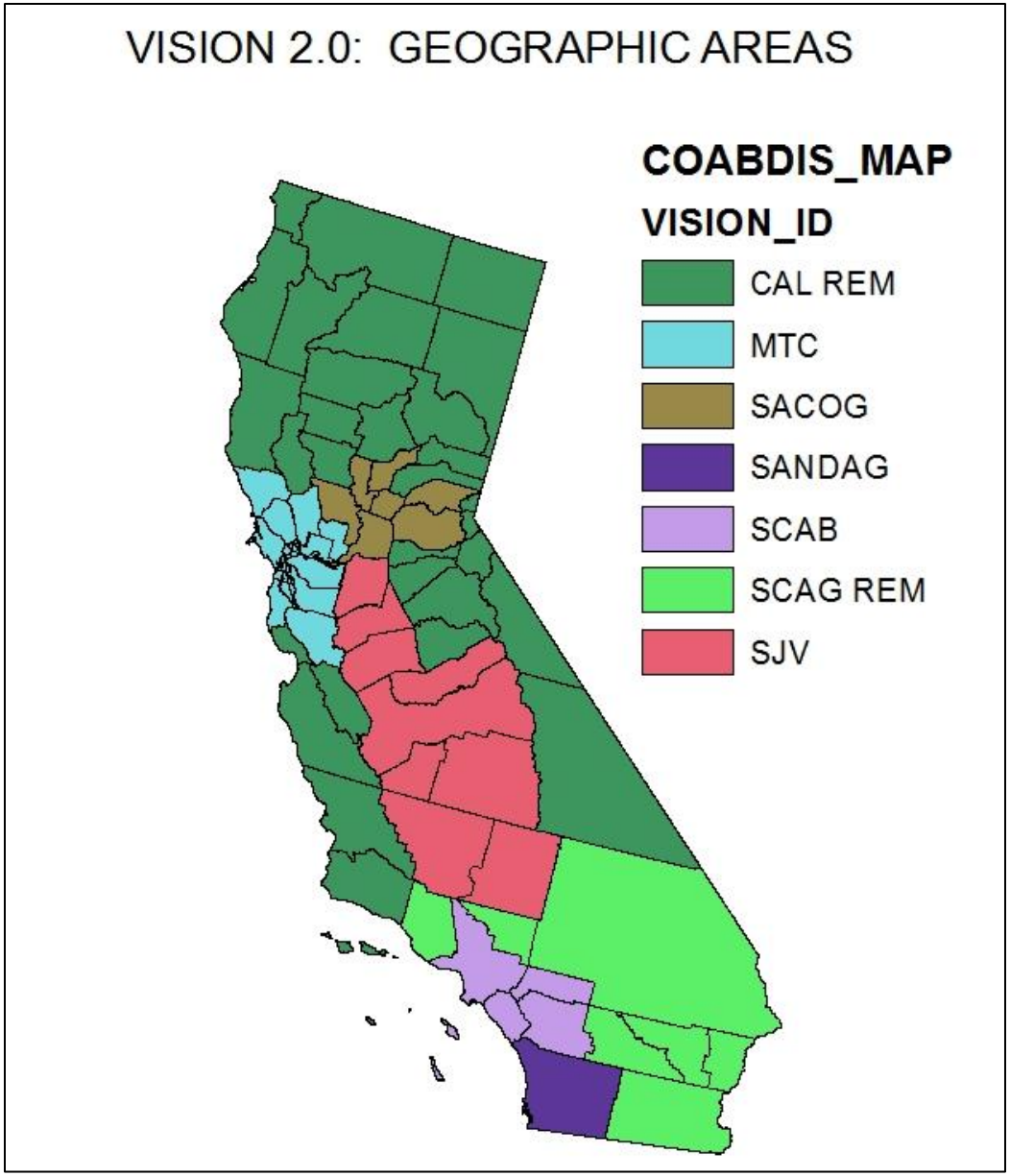
MODEL FUNCTIONALITY

- Works within EMFAC structure, with user defined segments of the population
- For certain population segments, user may define:
  - New Sales Fractions
  - VMT/trips
  - Survival curves
  - Emission rates & fuel economy

VEHICLE SPECIFICITY

- Vehicle types
  - LD Auto, LT1, LT2, MDV (up to 8,500 GVWR)
  - Urban and school buses
- Combustion
  - Gasoline, ethanol
  - Diesel
  - Natural gas
- Advanced Technologies –
  - Battery electric vehicle (BEV)
  - Fuel cell vehicle (FCV)
  - Plug-in hybrid electric vehicle (PHEV)

GEOGRAPHIC DOMAIN SPECIFICITY



POLLUTANTS & PROCESS SPECIFICITY

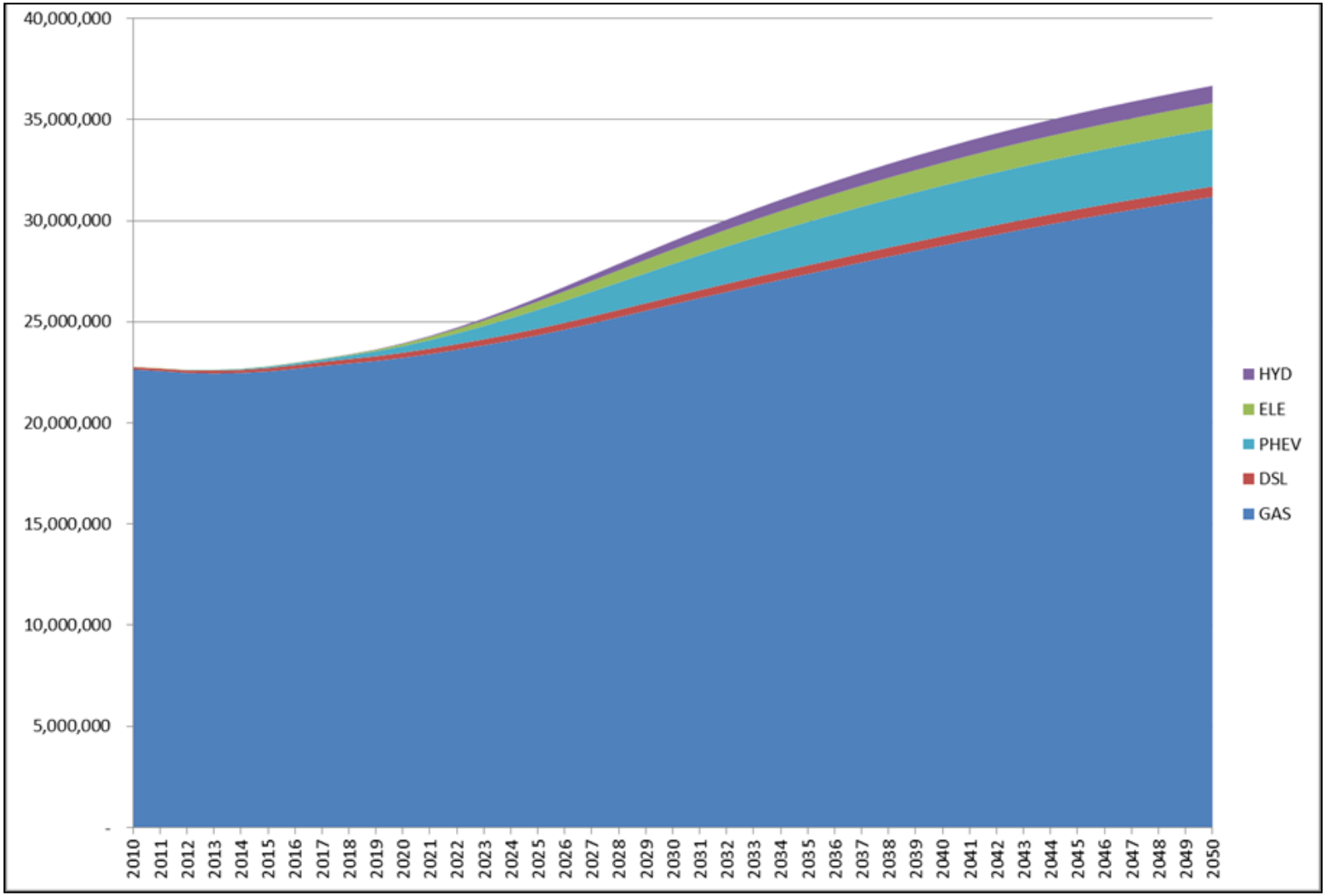
Fuel/Pollutant	Process	VISION Pollutant_Process
Fuel/Energy Consumption	Starting	Fuel/Energy Starting
	Idle	Fuel/Energy Running
	Running	
NOx	Starting Exhaust	NOx Starting Exhaust
	Idle Exhaust	NOx Running Exhaust
	Running Exhaust	
$PM_{2.5}$	Starting Exhaust	PM2.5 Starting Exhaust
	Idle Exhaust	PM2.5 Running Exhaust
	Running Exhaust	
	PM Tire Wear	PM BW_TW
	PM Brake Wear	
ROG/VOC	Starting Exhaust	ROG Starting Exhaust
	Idle Exhaust	ROG Running Exhaust
	Running Exhaust	
	Hot Soak	ROG Running Loss
	Running Loss	
	Resting Loss	ROG Resting Loss
	Diurnal Loss	

ASSIGNING ASSUMPTIONS TO TECHNOLOGIES NOT CURRENTLY IN EMFAC

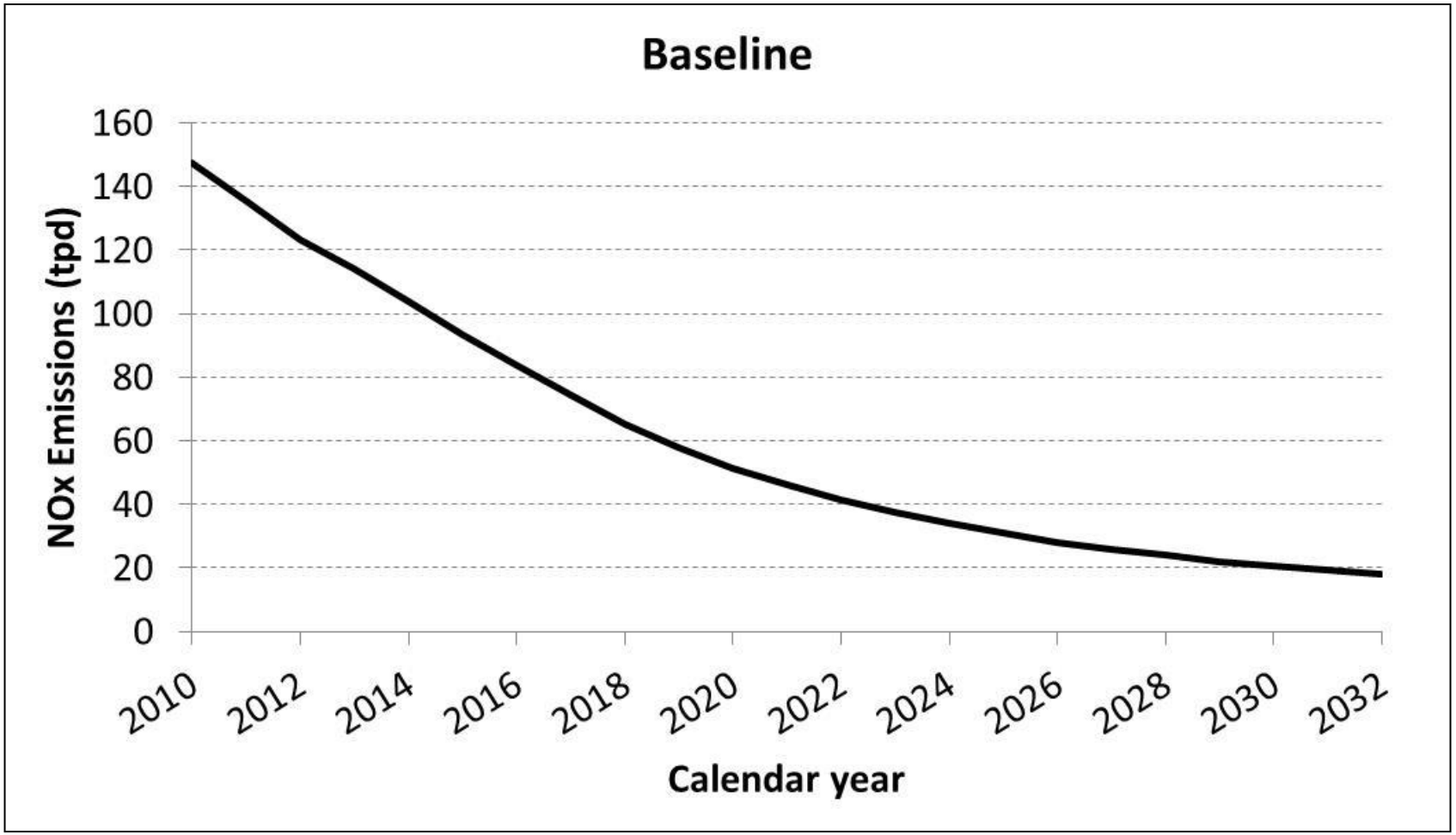
- Assumptions required for characteristics of alternative vehicle technologies not included in the EMFAC model:
  - Attrition rates
  - Accrual and trip rates
  - Emission factors/fuel consumption rates
  - Deterioration rates
  - eVMT split for PHEVs
- Current approach: match to conventional technologies in EMFAC based on similarities in engine, vehicle type and regional characteristics

POPULATION PROFILE OUTPUT

Statewide Passenger Vehicle Population Profile – Baseline Scenario



DAILY SCAB NOX: LDV+MDV+BUSES



Note: tpd = tons NOx per day

HEAVY DUTY VEHICLES

GOALS

- Heavy duty module focuses on freight vehicles over 8,500 lbs
- Overlay existing heavy duty inventory with any mix of:
  - Technology (defined by the user, not the model)
  - Population or VMT changes
- Maintain as much specificity as possible
- Flexibility to run baseline, incentive, turnover scenarios with any population, VMT, or technologies

DATA SOURCES

- EMFAC2014 – July 2014 draft version
  - Base Population
  - Emission Rates
  - Accrual and Trip Rates
  - Sales and Attrition Rates
  - Growth
- EMFAC2014 reflects all adopted policies for heavy duty vehicles including the Truck and Bus Rule and Phase I

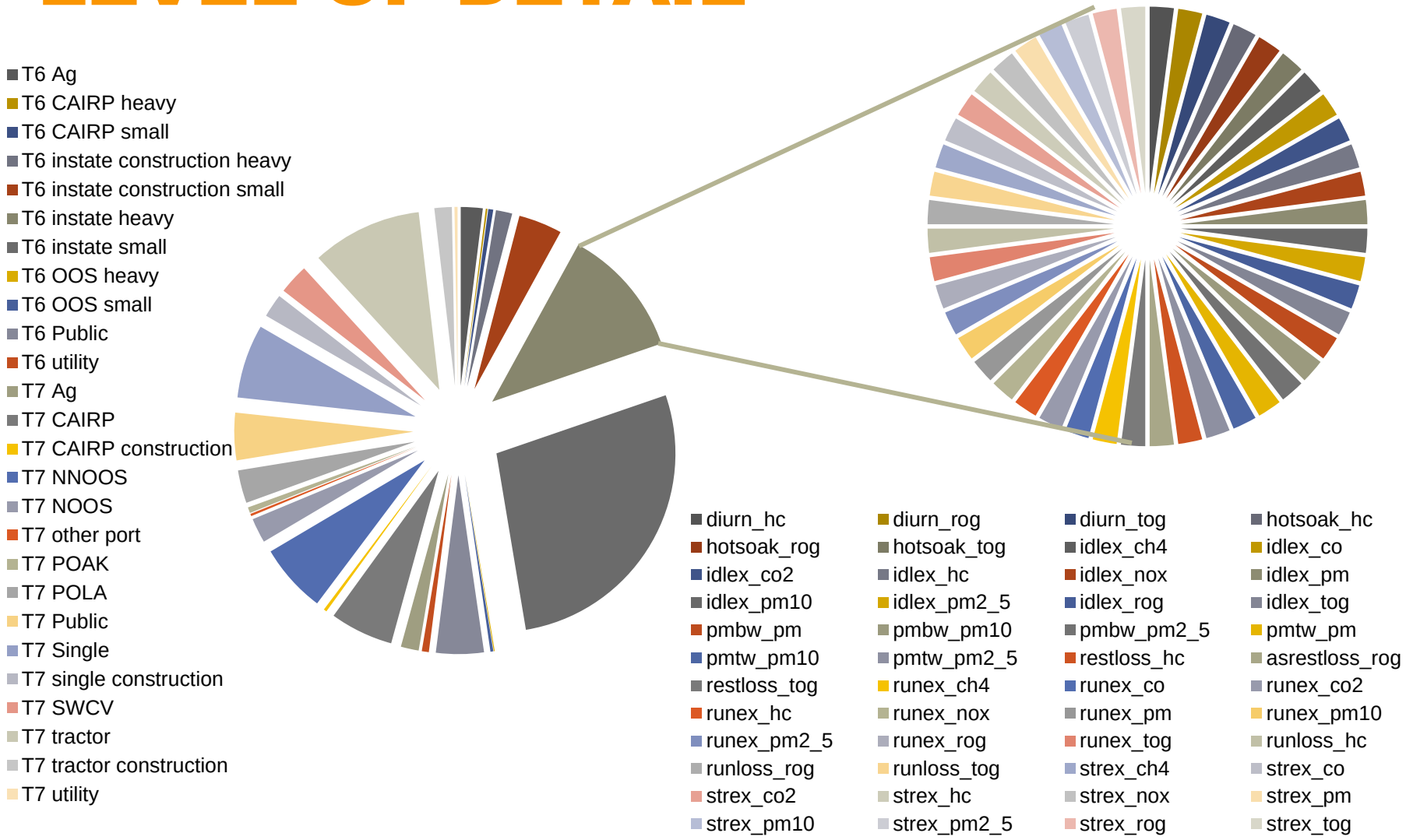
MODEL FUNCTIONALITY

- Works within EMFAC structure, with user defined segments of the population
- For population segments, user may define:
  - Population changes
  - Survival curve and purchasing
  - VMT
  - Emission rates & fuel economy

TRUCK MODEL SPECIFICITY

- Truck classification 2b to 8 (8,501+ GVWR)
  - EMFAC categories: LHDT1, LHDT2, MHDT, HHDT
- Technology
  - Any (engine, body, drivetrain, roadway, fuel/energy)
- Truck Type
  - Any LH/MH and HD, down to EMFAC detail level
- Location
  - Any (national, state, air basin, county, corridor)
- Scenario
  - Any (natural turnover, accelerated turnover, state rules, local rules, incentives, mode shifts, varying growth)

LEVEL OF DETAIL



Multiply by 7 Vision Regions or 69 COABDIS Regions, 20+Model years, and 40+ Years

TECHNOLOGY FUNCTIONS

Technologies can be introduced as:

1. Federal standards
   - All truck purchases including migration
2. State or local standards
   - Portion of new sales but no migration
3. Background survival and use rates
   - Activity and retirement set at same rate as truck fleet
4. Unique to technology
   - Activity and retirement set specific to technology

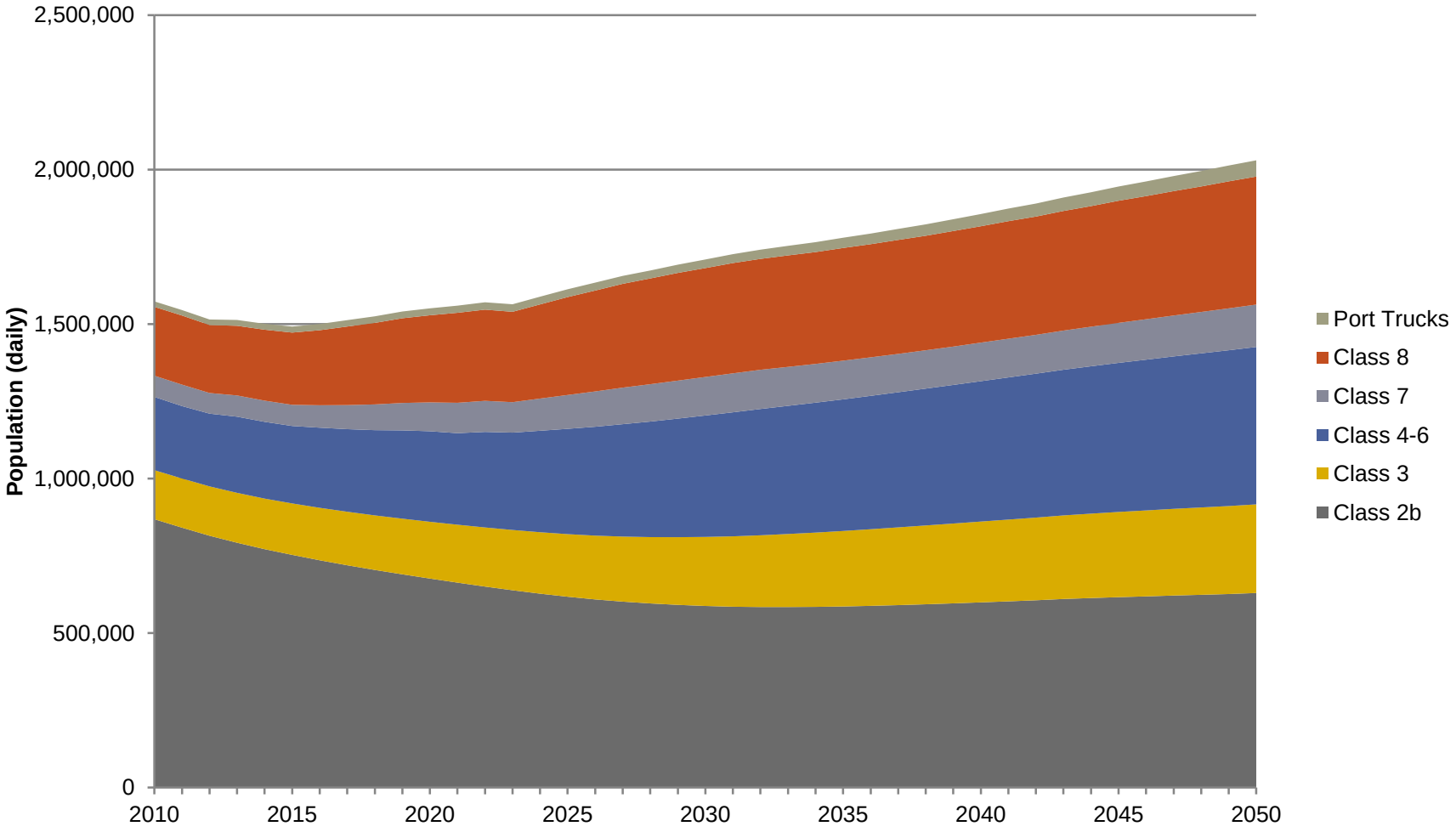
PURCHASING AND TURNOVER

- Purchasing and turnover functions derived from EMFAC data, specific to:
  - Truck type
  - Fuel
  - Vision region
- Can input scenarios with rules and accelerated attrition
  - Scenarios prior to 2023 require truck rule interaction

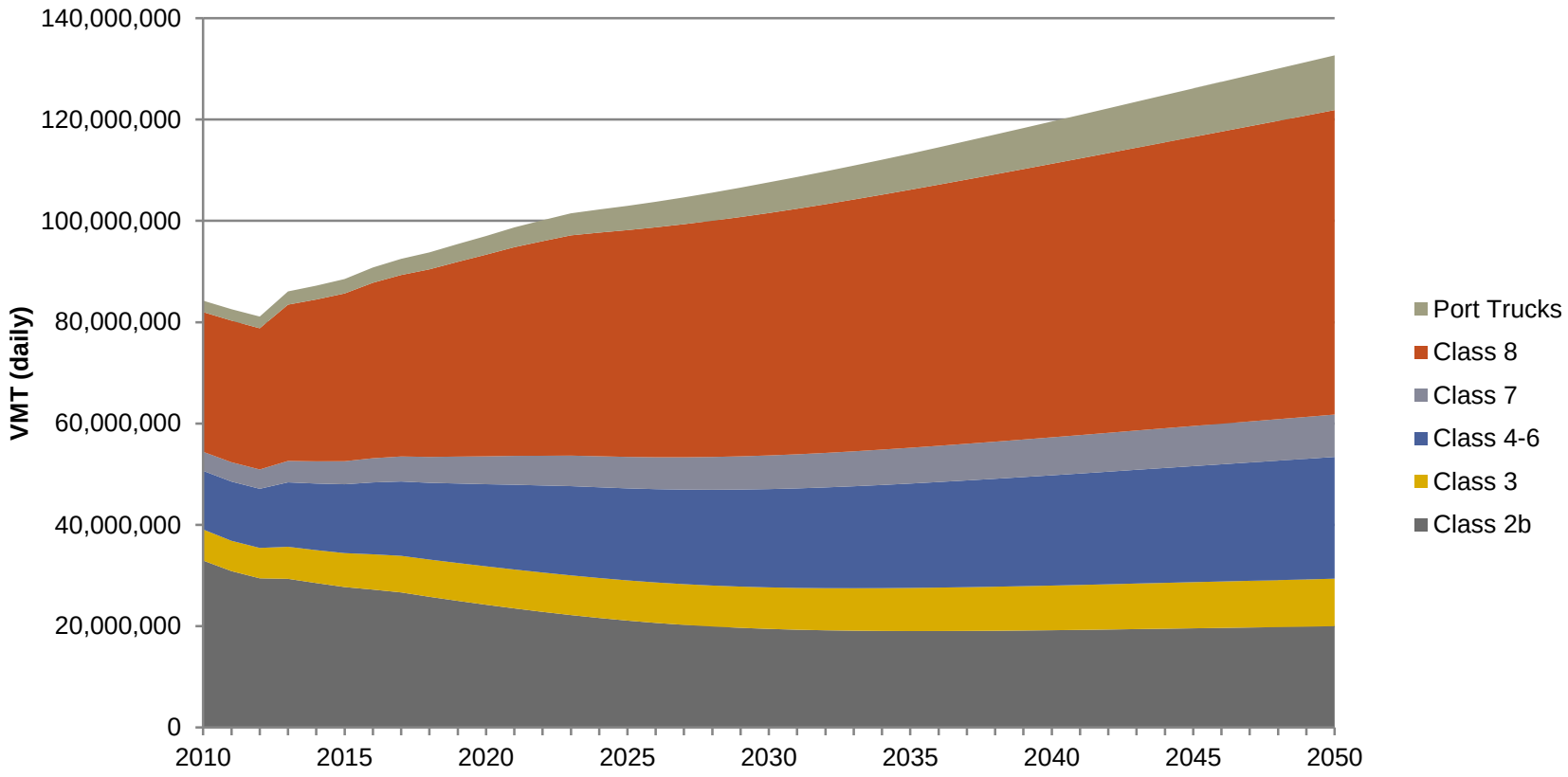
EXAMPLE OUTPUT

- Fleet average emission factors, technology mixes, emission reductions vs goals, etc
- Input factors, sales percent, additional purchases, etc
- These are preliminary results, will evolve as new scenarios are developed

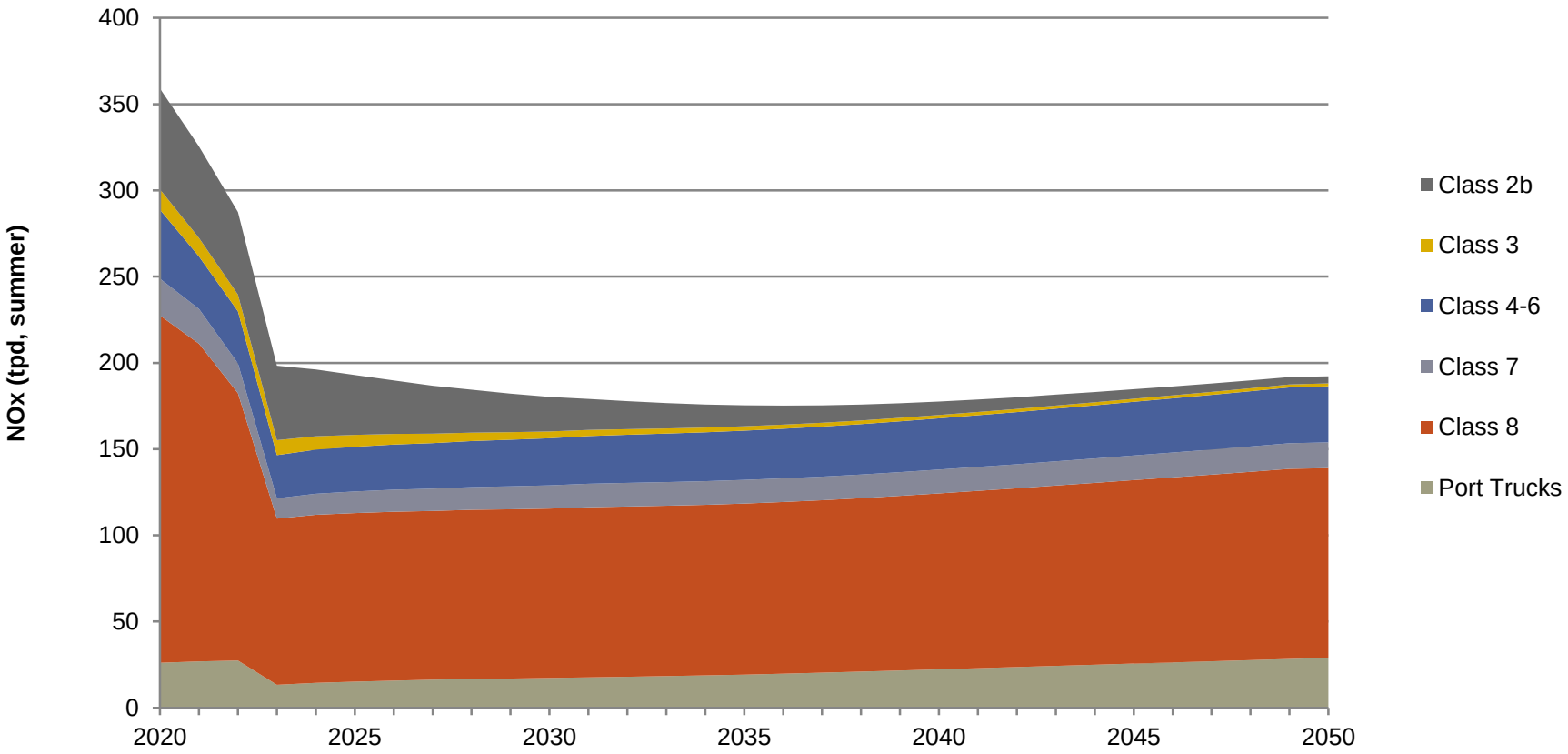
DAILY POPULATION



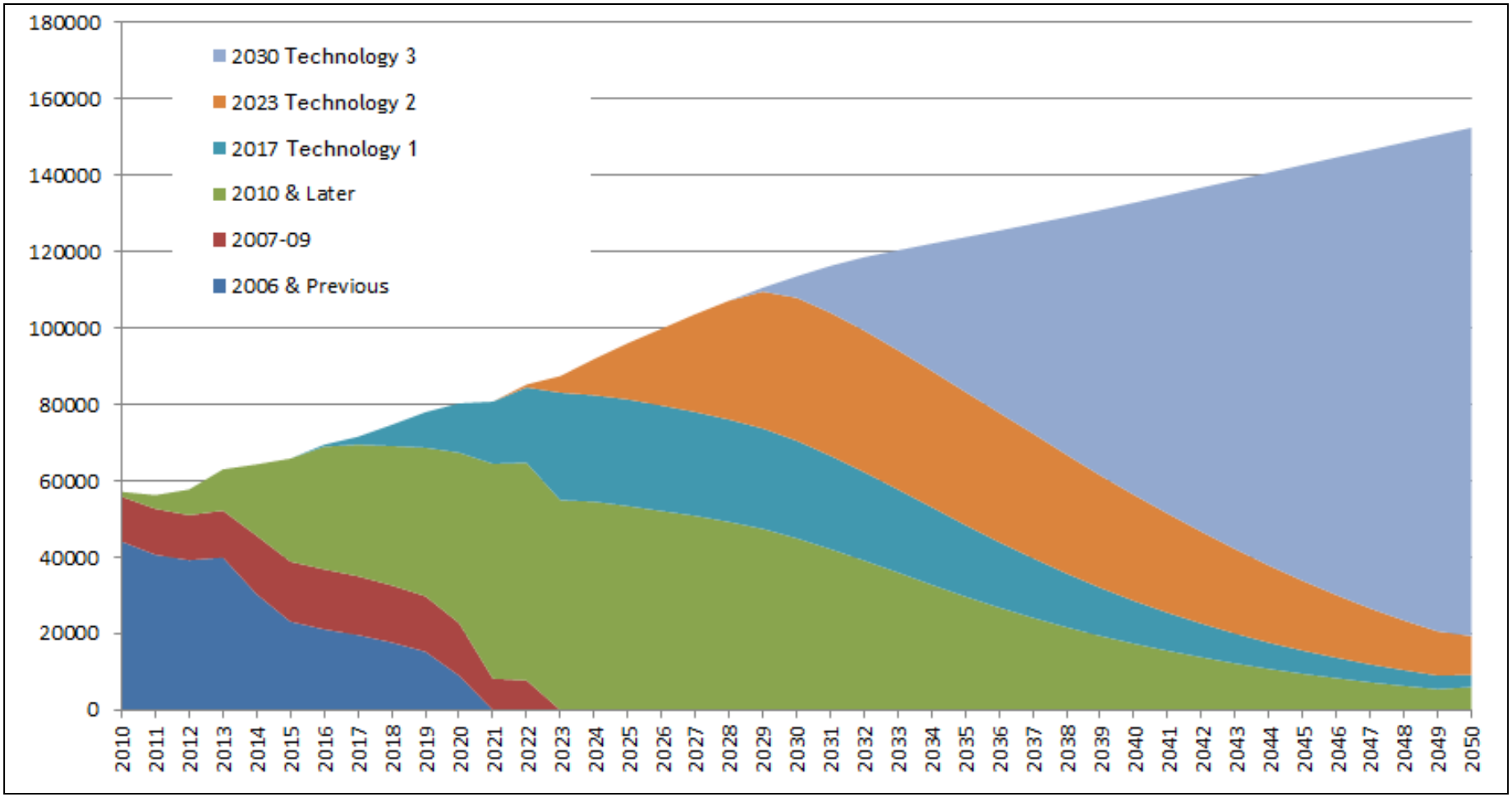
DAILY VMT


140,000,000
120,000,000
100,000,000
80,000,000
60,000,000
40,000,000
20,000,000
0
VMT (daily)
2010
2015
2020
2025
2030
2035
2040
2045
2050
Port Trucks
Class 8
Class 7
Class 4-6
Class 3
Class 2b

DAILY NOX


NOx (tpd, summer)
400
350
300
250
200
150
100
50
0
2020
2025
2030
2035
2040
2045
2050
Class 2b
Class 3
Class 4-6
Class 7
Class 8
Port Trucks

POPULATION SEGMENTS



ENERGY SECTOR MODULE & EMISSION FACTORS

ENERGY MODULE OVERVIEW

Energy Module Introduction

Overview of Module Mechanics

Emission Factors

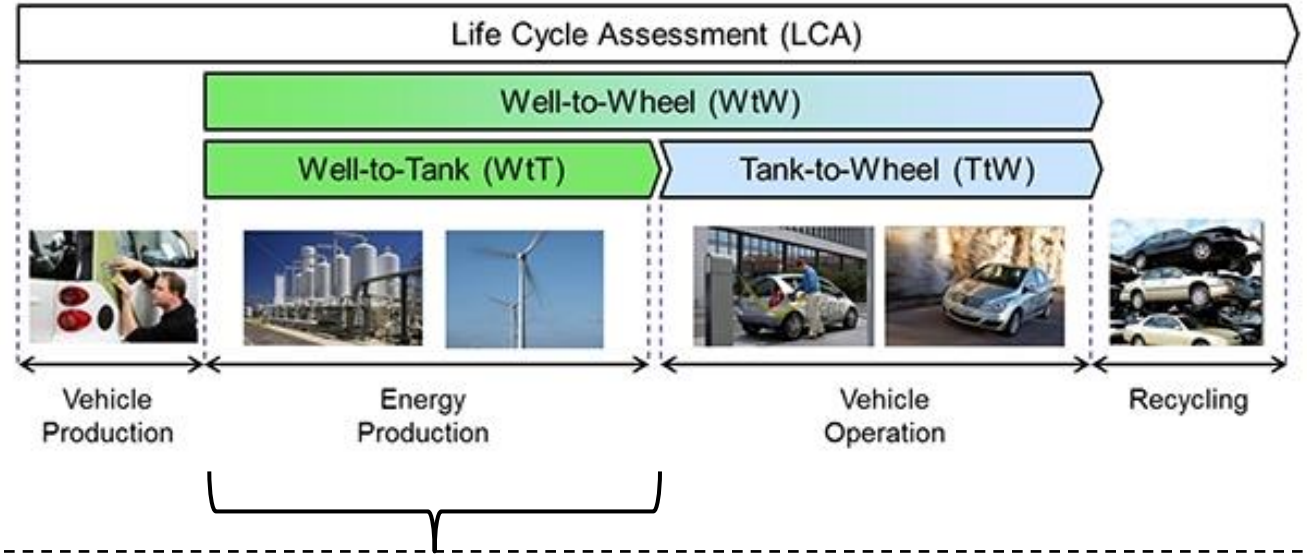
Assumed Blends/Supply

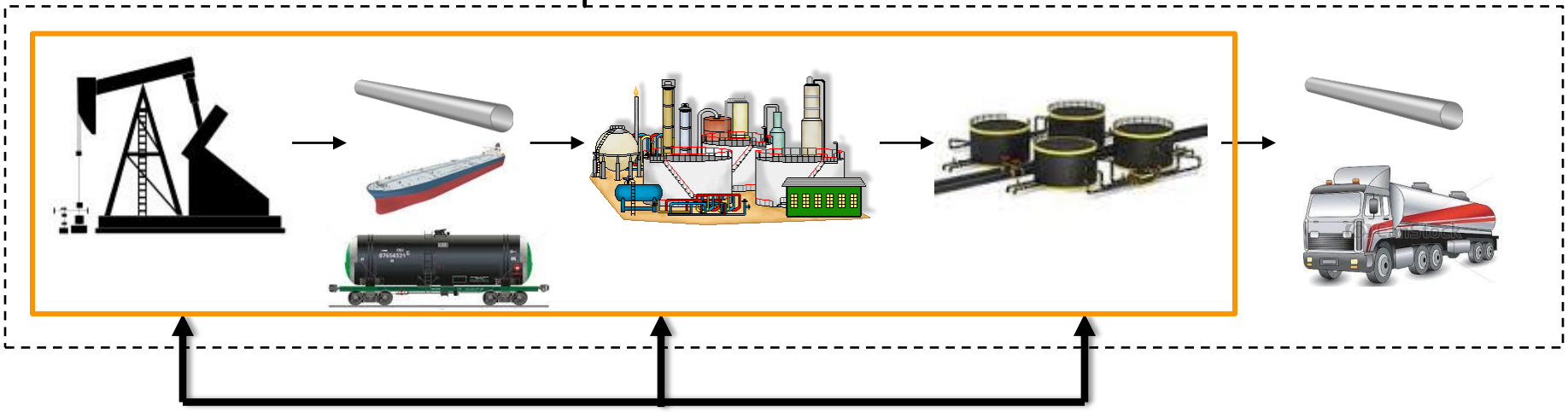
Future Development

ENERGY MODULE PURPOSE

- Aggregated energy consumption and multi-pollutant emissions associated with fuel demand
- Emission factors
  - “Well To Tank” (WTT) for Criteria Emissions
  - WTT+TTW for GHG Emissions – AB32 boundary
  - Full “Well to Wheel” for GHG – LCFS compliance
- Energy consumed
  - Finished fuels (gasoline, diesel, NG, LNG, H2, Elec)
    - Including renewable fuels
  - Feedstock resources (e.g. oil, corn, etc)

WELL-TO-WHEEL DESCRIPTION





CA-specific facility criteria emissions

ENERGY MODULE POTENTIAL

Policies to consider

- GHG and petroleum reduction targets
- LCFS variations
- Renewable Portfolio Standard (RPS) variations
- SB1505 – Renewable Hydrogen
- EO S-06-06 – In-state biomass supply

Strategies

- Carbon Intensity (CI) for advanced biofuels
- Biomass feedstock competition for biofuels and biopower
- Spatial location of upstream emissions and facilities
- Methane leakage sensitivity

ENERGY MODULE MECHANICS

- End-use Sector Demands are aggregated into “fuel bundles”
  - Benefits of low CI fuels are equally distributed across all end-use sectors
- Emission Factors
  - Multiplied by demand to produce emissions associated with fuel/energy production
- Blending/Supply
  - Allows an arbitrary blend (eg 9.7% EtOH)
  - Module can optimize blends to fully utilize low CI supplies
  - Supply mix choices for electricity and hydrogen production
  - Ensures supply capacities are not exceeded

VISION 2.0 DEMAND TO SUPPLY

Demand Sectors

Mobile Sources

- Passenger vehicles
- Heavy-duty vehicles (on-road)
- Freight locomotives
- Aviation
- Off-road Sectors

Stationary Sources

- Residential and commercial buildings

Blendstocks potentially consumed to meet demand

Diesel

- Ultra Low Sulfur Diesel
- Soy Oil Bio-Diesel
- Advanced Bio-Diesel
- Renewable Diesel

Gasoline

- CA RBOB
- Corn Ethanol
- Advanced Ethanol
- Renewable Gasoline

Jet Fuel

- Kerosene Jet Fuel
- Renewable Jet Fuel

Natural Gas

- Fossil Natural Gas
- Dairy Digester Gas
- Landfill Gas
- Renewable Natural Gas

Hydrogen

- Central NG Reformed H_2
- Distributed NG Reformed H_2
- Bio- H_2
- Central Solar H_2
- Central Wind H_2

Electricity

- Coal Generated Power
- Biomass Generated Power
- Geothermal Generated Power
- Large Hydro Generated Power
- Natural Gas Generated Power
- Nuclear Generated Power
- Small Hydro Generated Power
- Solar Generated Power
- Wind Generated Power

WELL-TO-TANK EMISSION FACTORS: UPSTREAM FUEL PRODUCTION

CA-specific statewide averages for upstream fuel production (g/mmbtu)

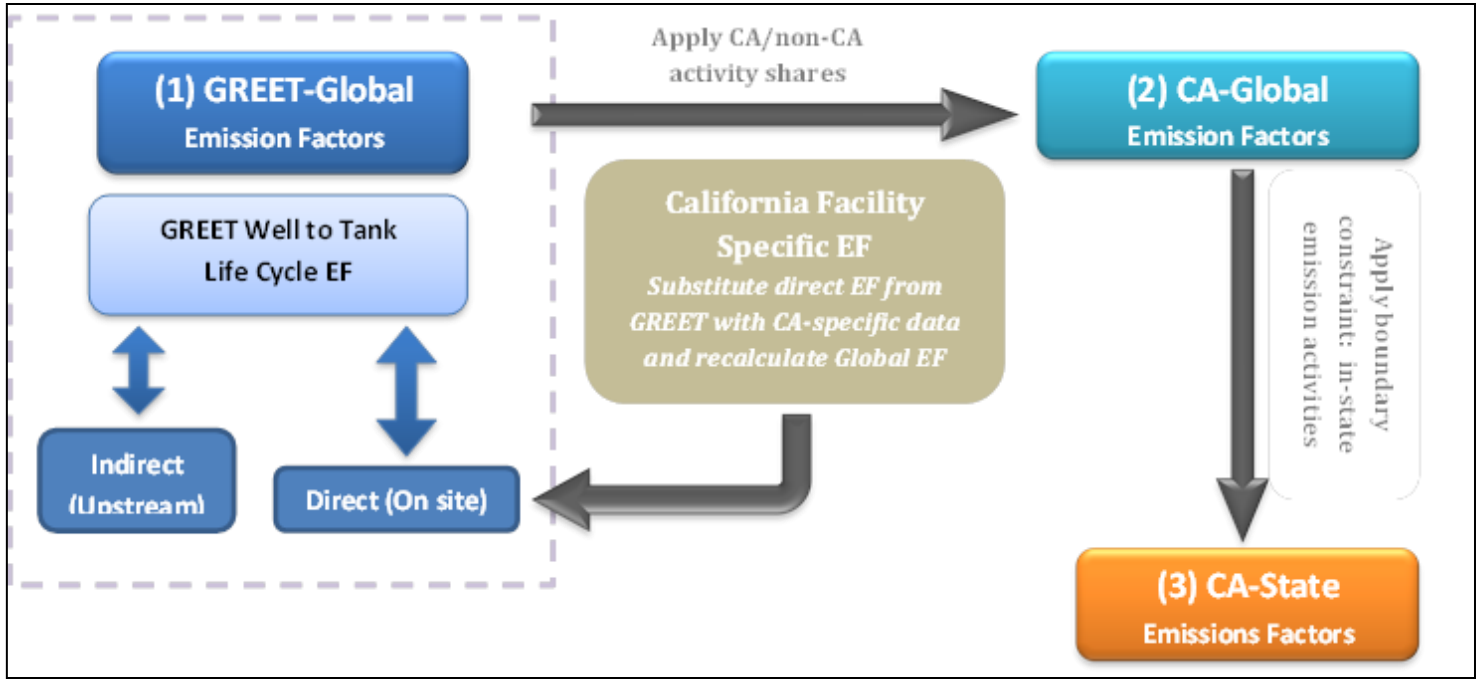
- Criteria pollutant EFs using:
  - CA-specific facility emissions (ARB criteria pollutant emission inventory)
  - CA-specific fuel production throughputs/capacities (CEC, DOGGR, DOE)
  - GREET 2013 national averages for non-facility indirect processes

- GHG EFs using:
  - CA GHG emissions Inventory
  - CA-specific fuel production throughputs/capacities (CEC, DOGGR, DOE)

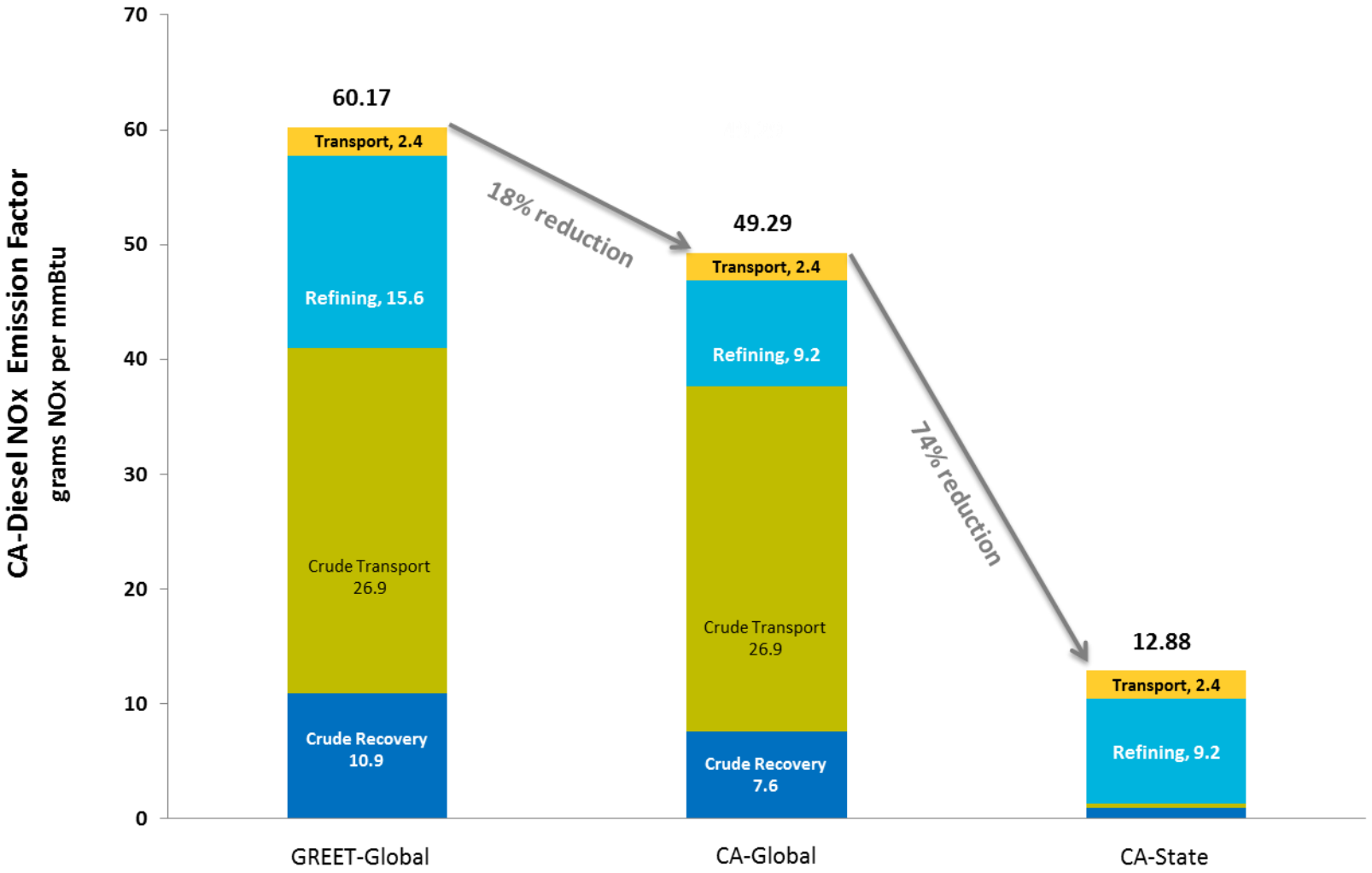
- Fuels currently not produced in CA:
  - Default GREET national average emission factors
  - Scaled using emission factor differences between an average CA refinery vs. a national refinery (conventional fuel production)

CRITERIA POLLUTANT EMISSIONS: BOUNDARY CONSIDERATIONS

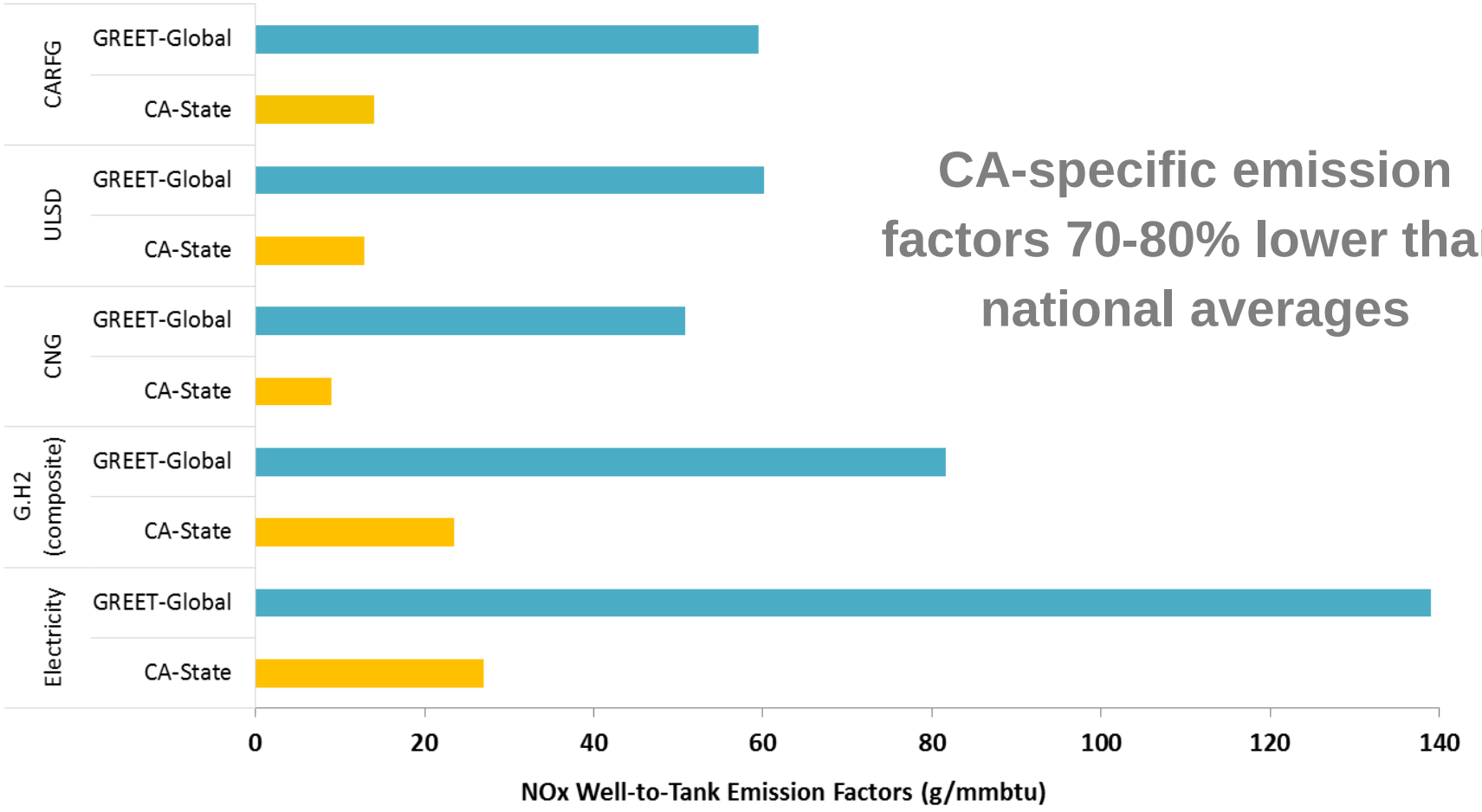
- CA-Global: Reflects CA-specific facility emissions for fraction of fuel production in-state
  - Direct (on-site) emission factors from GREET substituted with CA-specific data
  - Indirect (upstream) emission factors from GREET 2013
- CA-State: CA-Global emission factors constrained to state boundary
  - Fuel production activities in-state and within 100 nautical miles of state border



WTT NOX EMISSION FACTORS: SPATIAL BOUNDARY EFFECTS

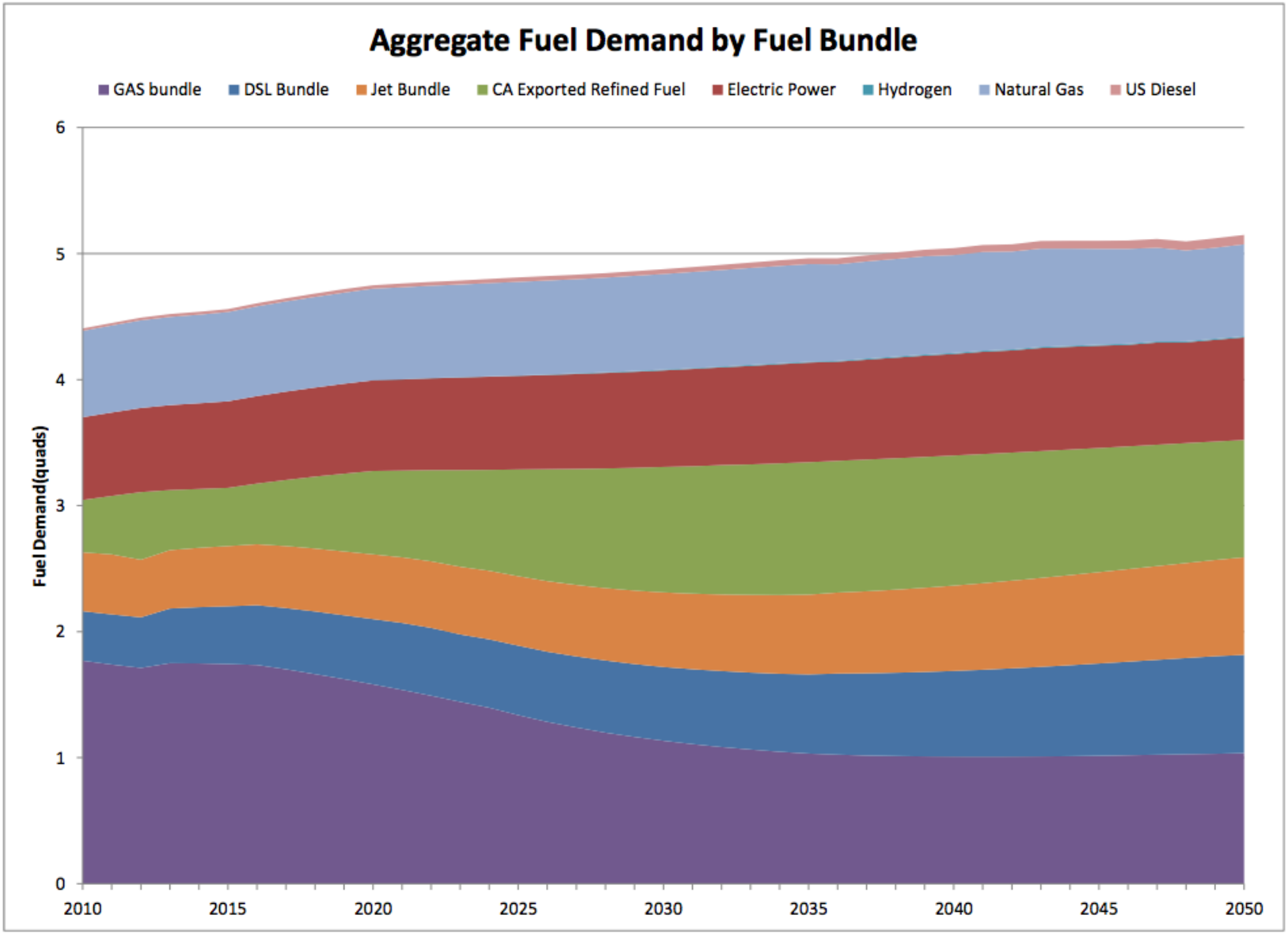


WTT NOX EMISSION FACTORS: SPATIAL BOUNDARY EFFECTS



CA-specific emission factors 70-80% lower than national averages

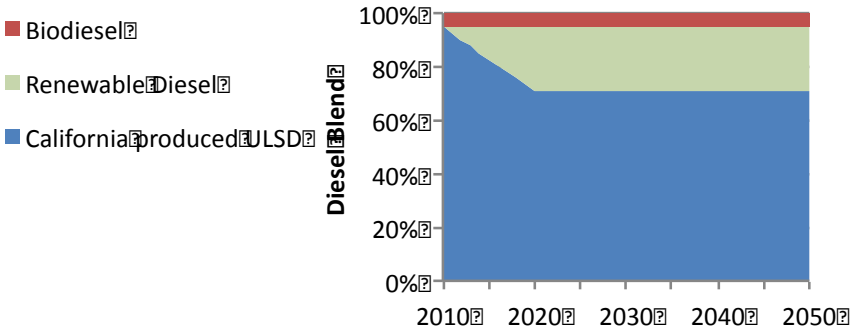
BASELINE RESULTS



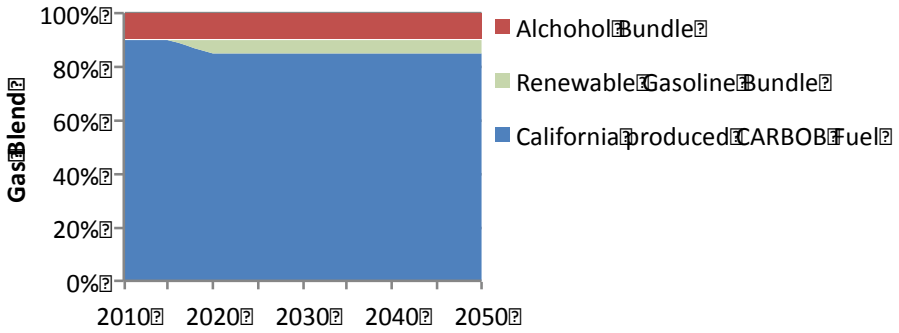
Note: quad = quadrillion BTUs

BASELINE FUEL BLENDING

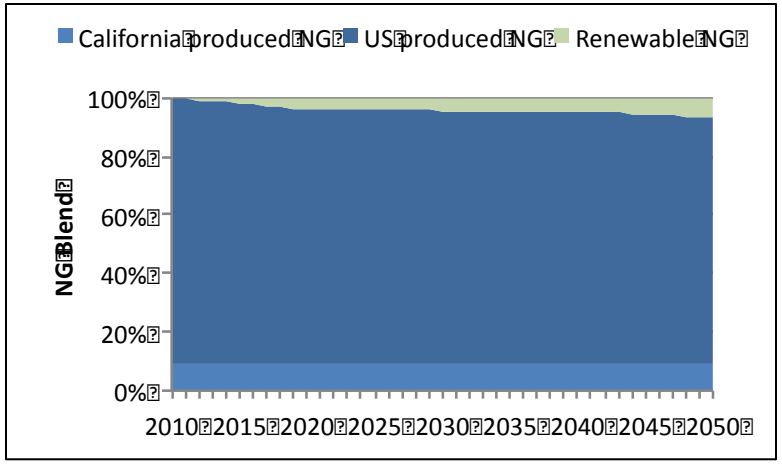
Diesel



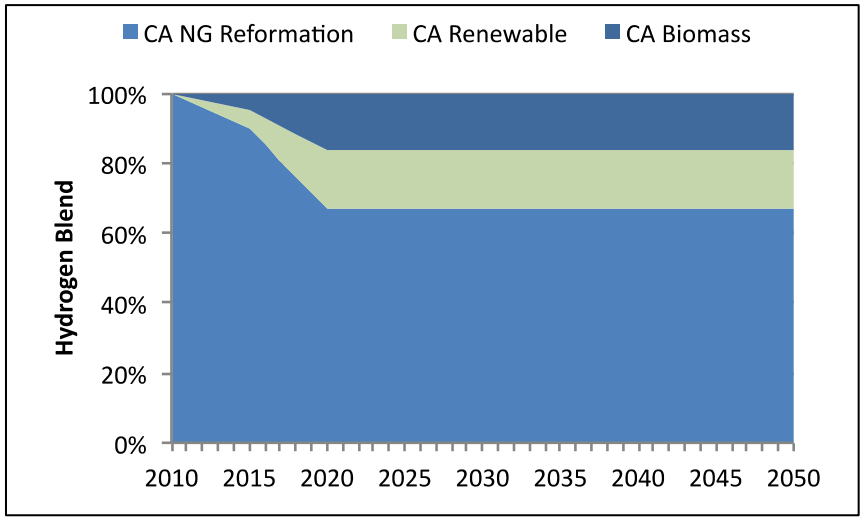
Gasoline



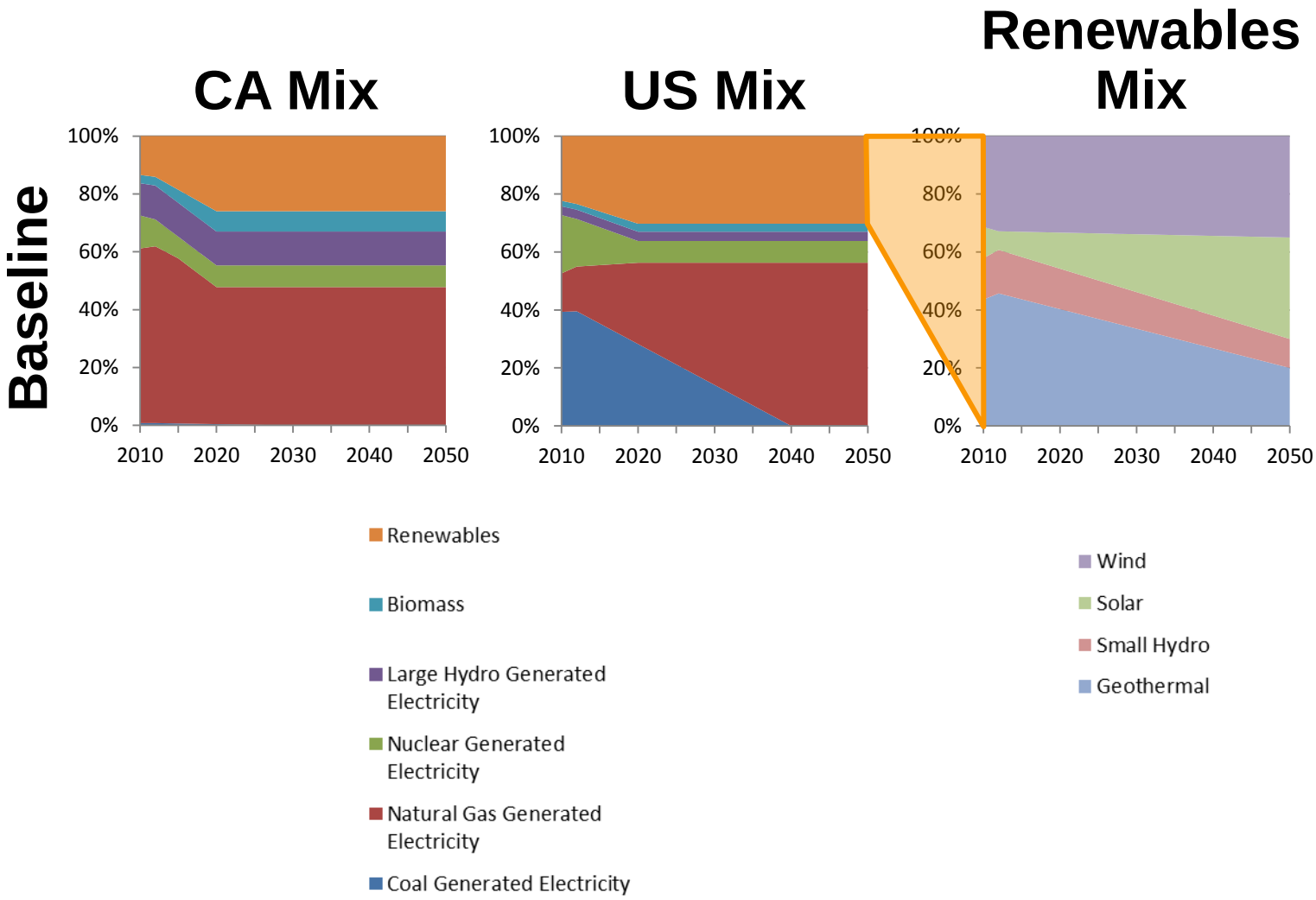
Natural Gas



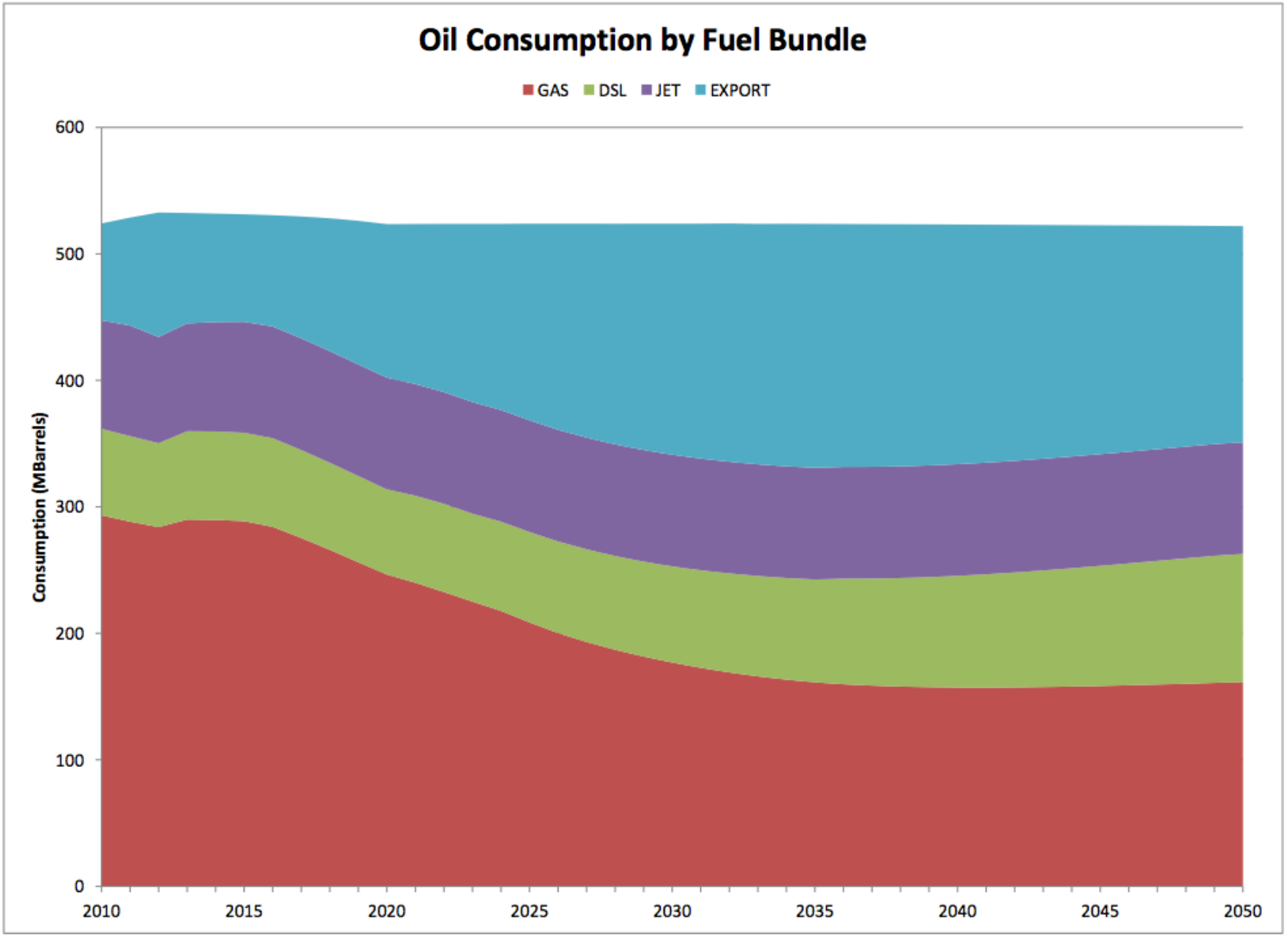
Hydrogen



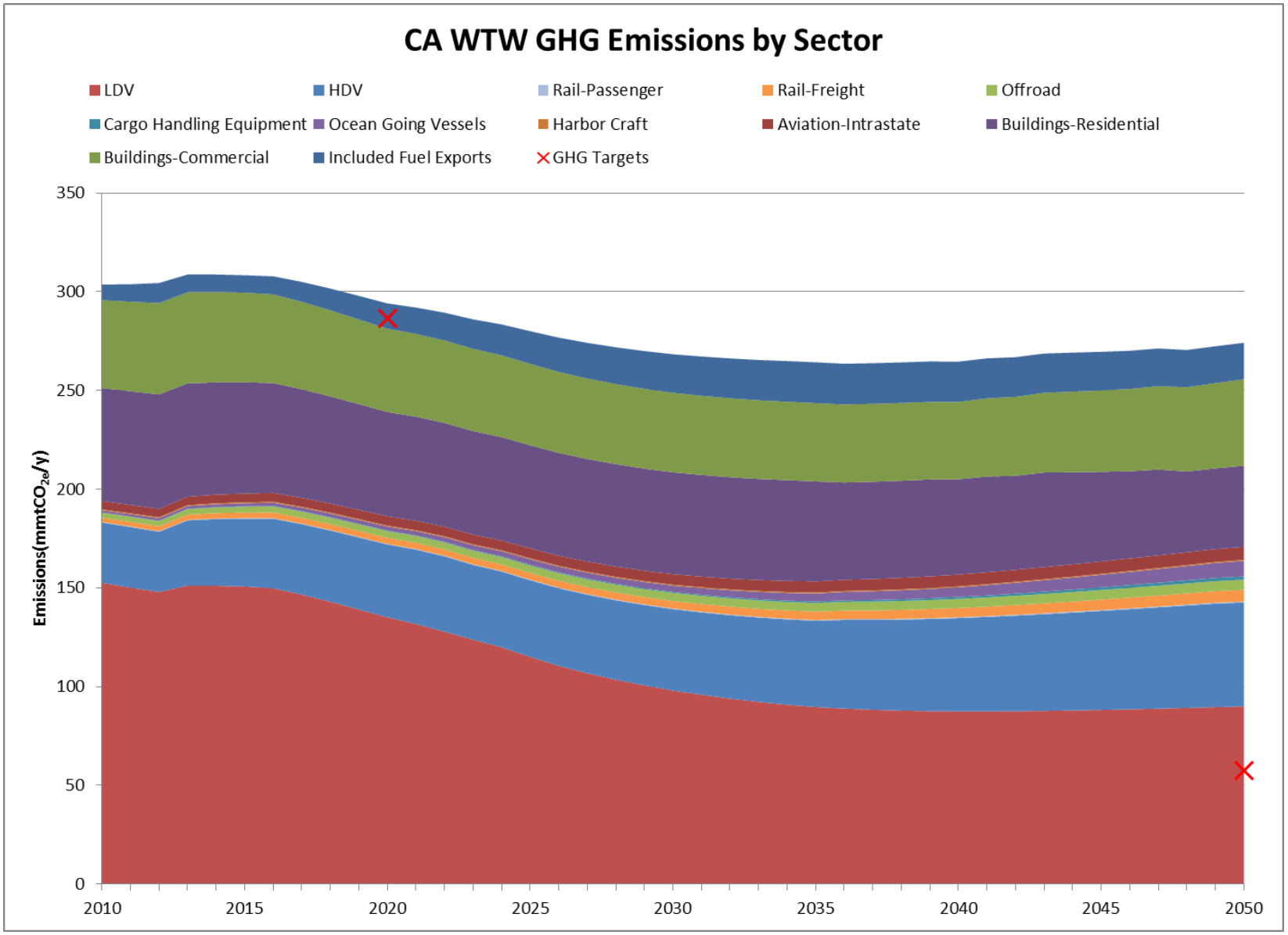
BASELINE ELECTRICITY GENERATION MIX



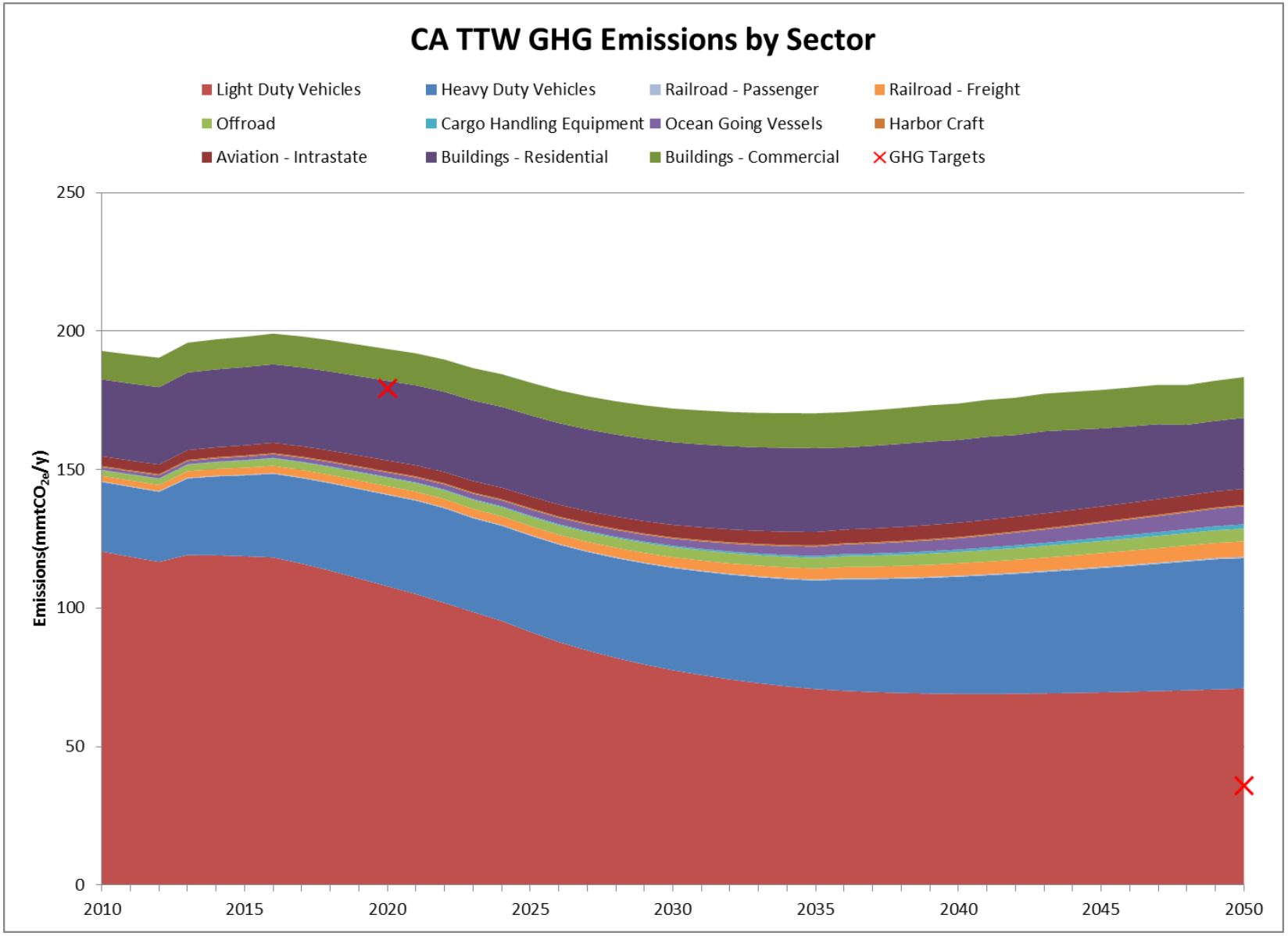
BASELINE RESULTS



BASELINE RESULTS



BASELINE RESULTS



FREIGHT RAIL

DATA SOURCES

- Updated locomotive inventory
  - Summarized in prior workshop presentation: http://www.arb.ca.gov/msei/goods_movement_emission_inventory_line_haul_octworkshop_v3.pdf

- Inventory reflects all adopted policies including 1998 South Coast MOU

USER INPUT

Parameters

- Technology
- Fuel Efficiency
- Tier Distribution/Penetration
- Fuel Sulfur Content
- Activity
- Speed Changes

ADVANCED TECHNOLOGY

- Baseline model assumes 100% diesel and impact of 1998 MOU, South Coast/spillover
- User can select penetration of advanced technology by air basin, calendar year
  - Technology – e.g. combustion, battery electric, catenary, fuel cell, natural gas
  - Technology Performance – e.g. Tier 4, Tier 4 + aftertreatment, zero-emission tailpipe

OTHER SCENARIO OPTIONS

Corridor-specific fuel reduction cases

- “Accelerated turnover”
- Congestion reduction (at-grade right of way)
- Weight/drag reduction
- Other efficiency improvements

PASSENGER RAIL

PASSENGER RAIL

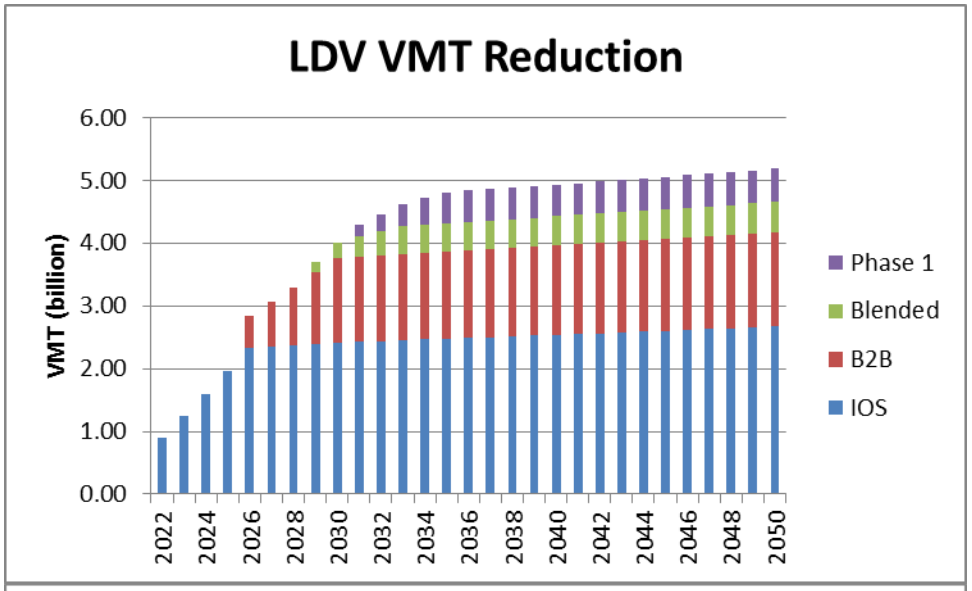
- **Utilizes Official ARB Inventory**
- **Module Input Variables**
  - Fleet efficiency
  - Activity
  - Fuel switching
  - Emissions Tier distribution
- **Future Years**
  - Forecasted Locomotive Population
- **Output results**
  - GHG, Criteria Pollutants, total fuel usage
- **High Speed Rail (HSR)**
  - Based on HSR Authority 2012 High Speed Rail Plan
  - Determines VMT and air trip reductions

ASSUMPTIONS

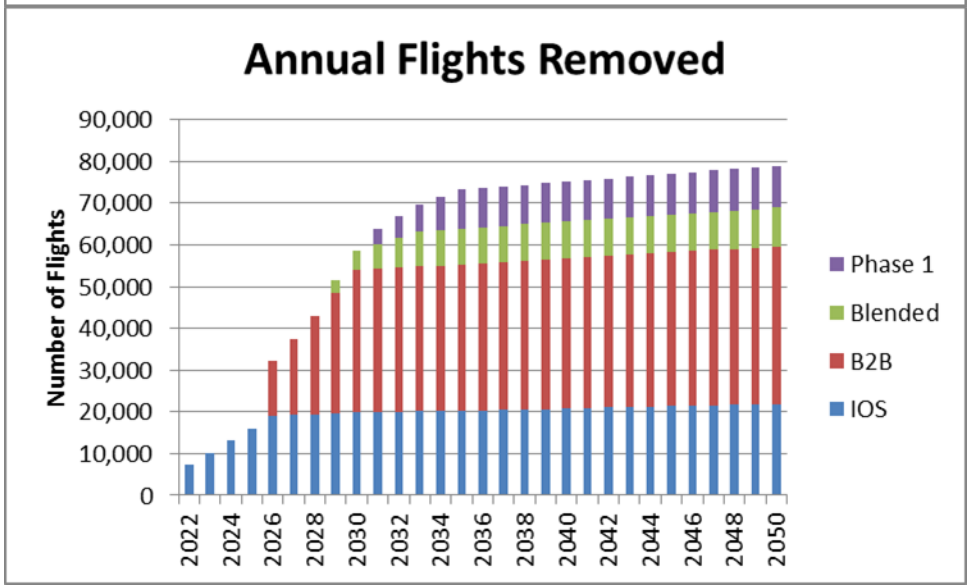
- Baseline
  - Passenger rail activity demand matched to Caltrans CTP 2040
  - Fuel Efficiency flat-lined
  - High Speed Rail (HSR) not included in baseline
- Future scenario can include HSR
  - HSR Authority data and build-out scenario
    - Reduces Intrastate aviation trips
    - Reduces LDV VMT statewide

EXAMPLE HSR AUTHORITY DATA

~1.4% of 2030 LDV VMT Removed by HSR



~12% of 2030 intrastate flights Removed by HSR



AVIATION

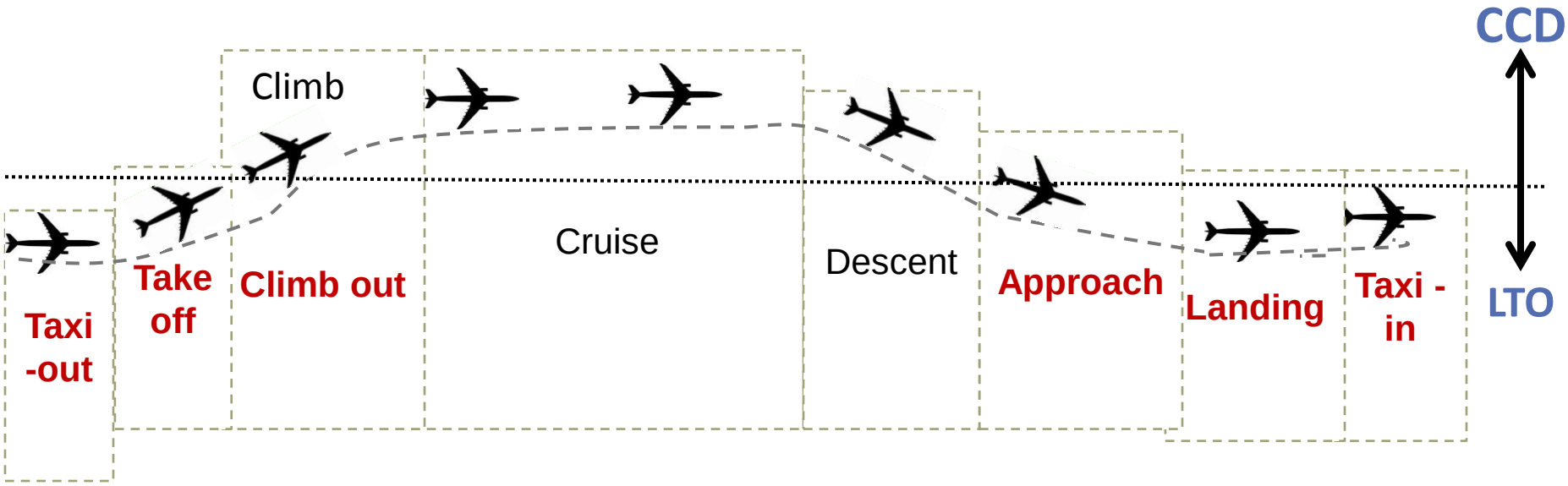
AVIATION DATA APPROACH

- **Goals for this module**
  - Split out emissions from taxi mode
  - Split out freight activity from commercial
  - Study entire aviation sector fuel demand for biofuel strategies
  - Bottom-up trip aggregation approach (2000 – 2012)
- **Data Sources**
  - Aircraft flight data - RITA BTS (2000 – 2012)
    - Includes all flights, all airports, distances, etc
  - Fuel sales - EIA data for California (2000 - 2012)
  - Aircraft emissions and fuel efficiency
    - ESAS ICAO emissions data bank (2013)

AVIATION MODULE

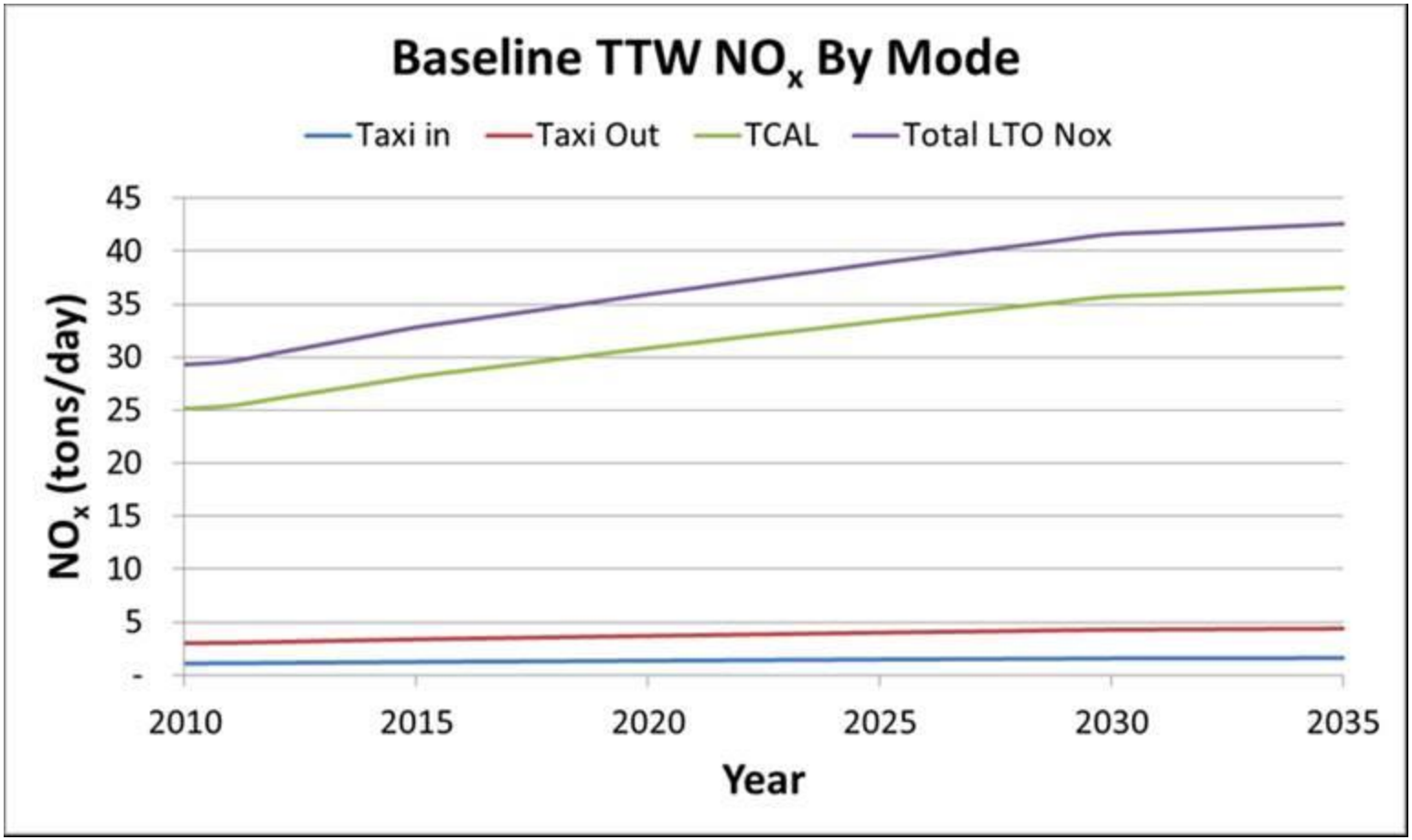
- **Module detail**
  - Flight identification
    - Year
    - Destination (intrastate, interstate, international)
    - Flight type (passenger, freight, mixed, mail)
  - Flight mode
    - LTO – “Landing & Take-off” (below 3,000 ft)
    - CCD – “Climb, Cruise & Descent” (above 3,000 ft)
- **Input variables**
  - Freight movement, passenger growth, taxi-bot, FE / yr, additional criteria reductions
- **Output results**
  - Emissions - GHG, Criteria Pollutants
  - Fuel demand

DESCRIPTION OF FLIGHT MODES

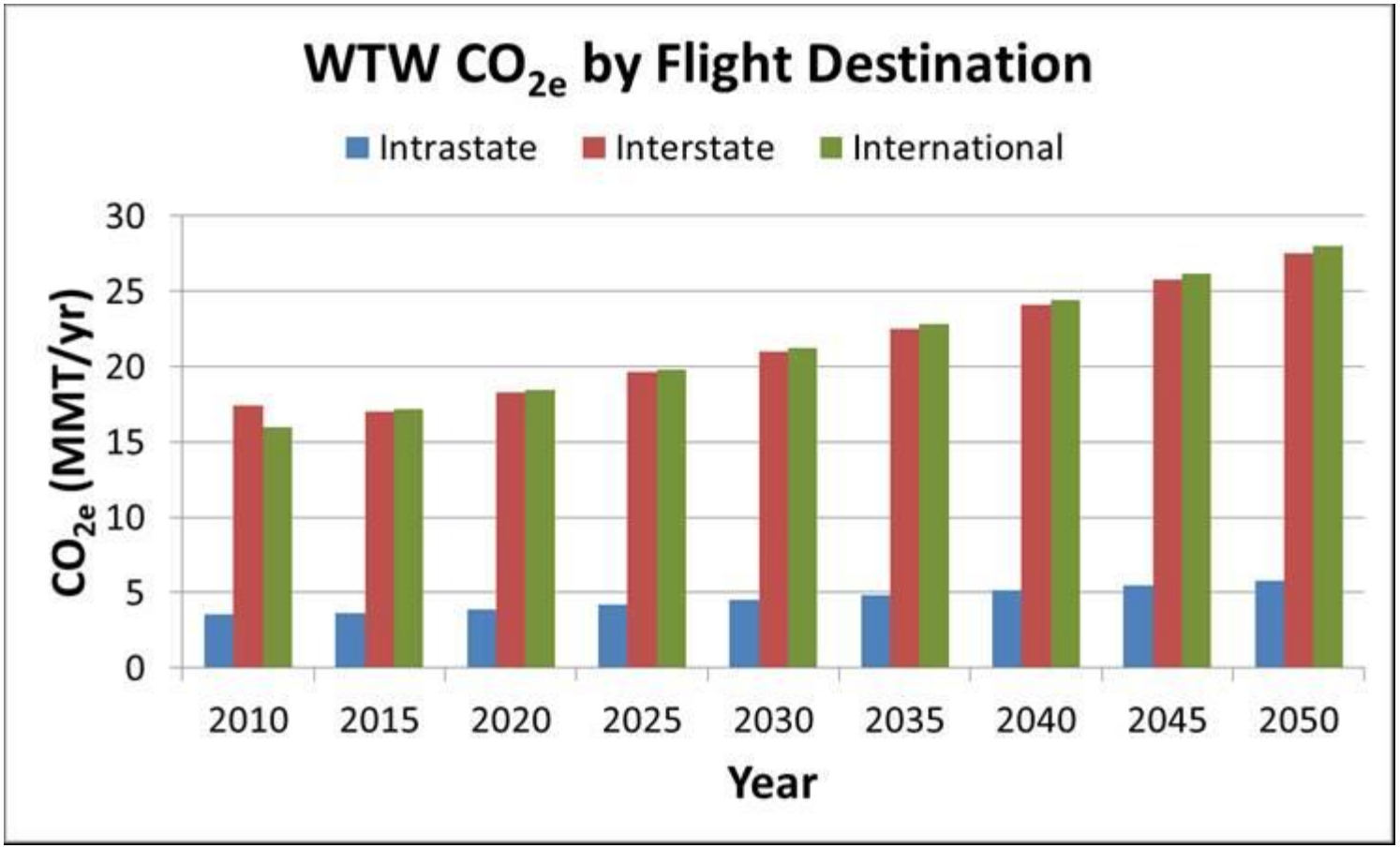


Emissions are based on engine type, # of engines and mode of operation

STATEWIDE AIRCRAFT NOX



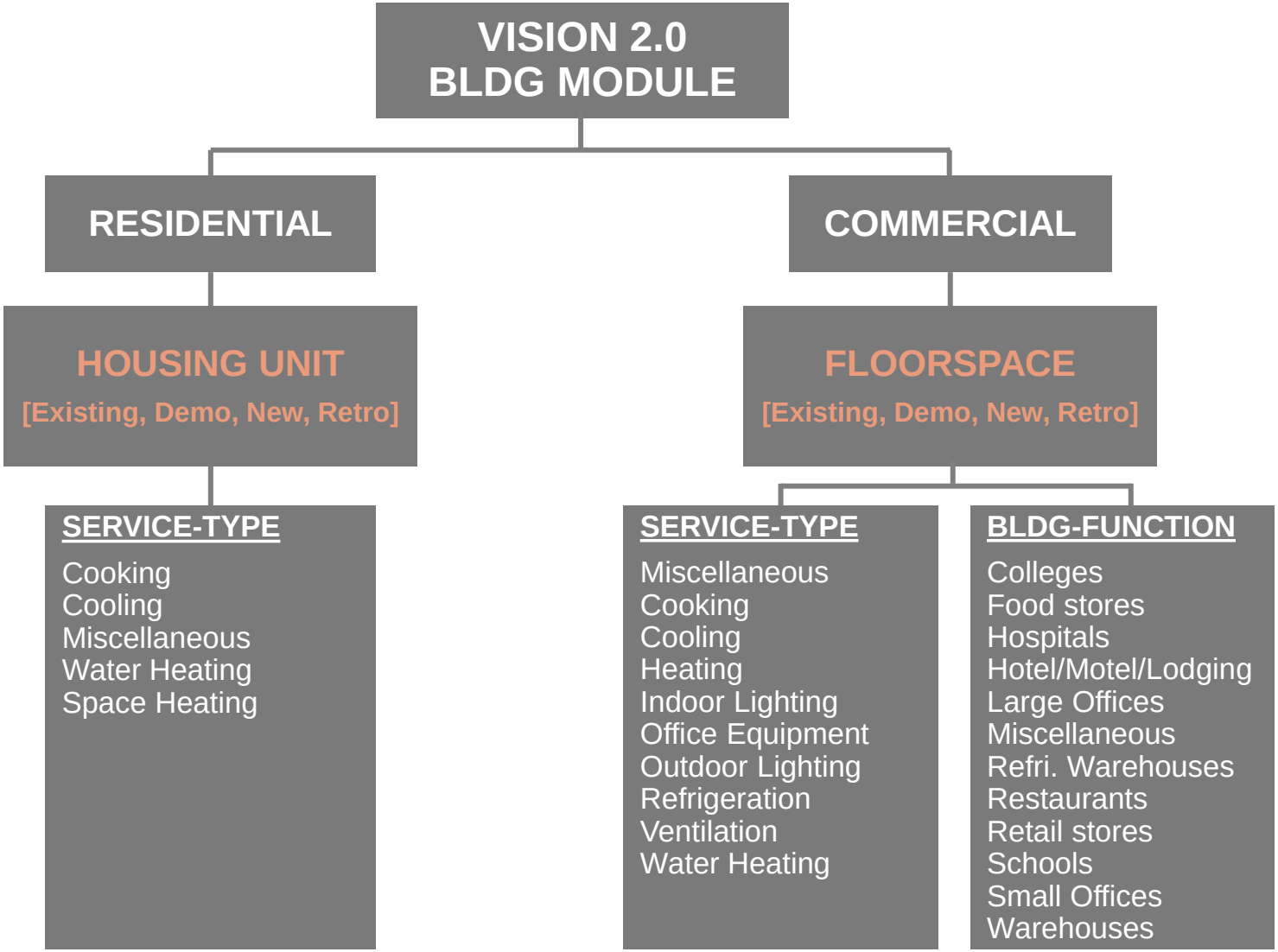
STATEWIDE AVIATION GHG



BUILDING MODULES

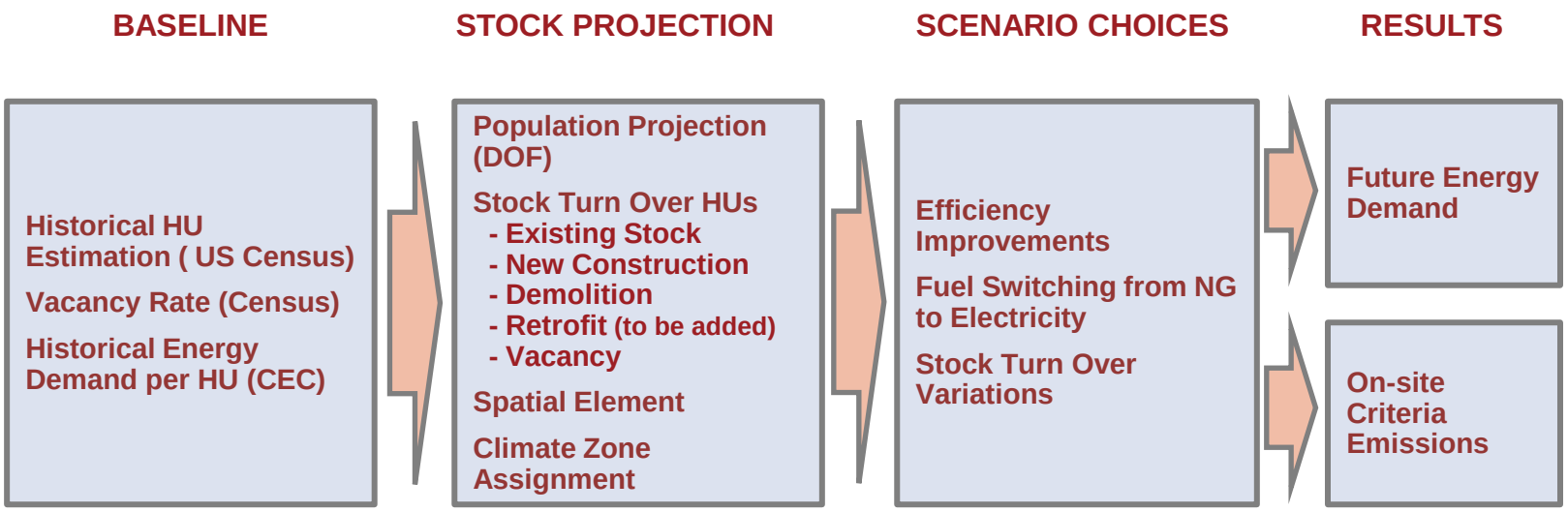
BUILDING ENERGY DEMAND

SECTOR METRICS FOR STOCK INVENTORY



RESIDENTIAL BLDG ENERGY DEMAND

STRUCTURE



METHODOLOGY

FIXED PARAMETER

- Historical Energy Demand
- Population Projection
- Historical HU Amount and Distribution
- End Use Appliances Distribution

VARIABLE INPUT PARAMETER

- Vacancy Rate
- Demolition Rate
- Retrofit Rate
- End Use Appliance Efficiency
- ZNE
- End Use Appliance Demand Distribution

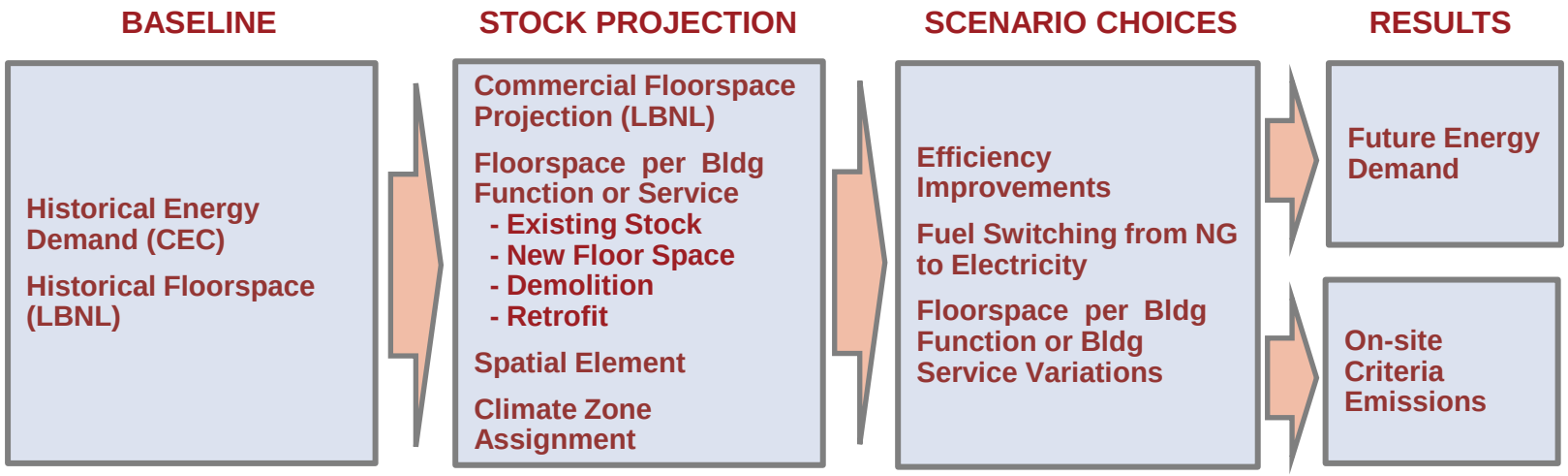
OUTPUT

- HU Projection (building stock)
- Energy Demand per Building Type
- Criteria Emission Estimation

Note: HU = housing unit

COMMERCIAL BLDG ENERGY DEMAND

STRUCTURE



METHODOLOGY

FIXED PARAMETER

- Historical Energy Demand
- Commercial Floorspace Projection
- End Use Appliances Distribution

VARIABLE INPUT PARAMETER

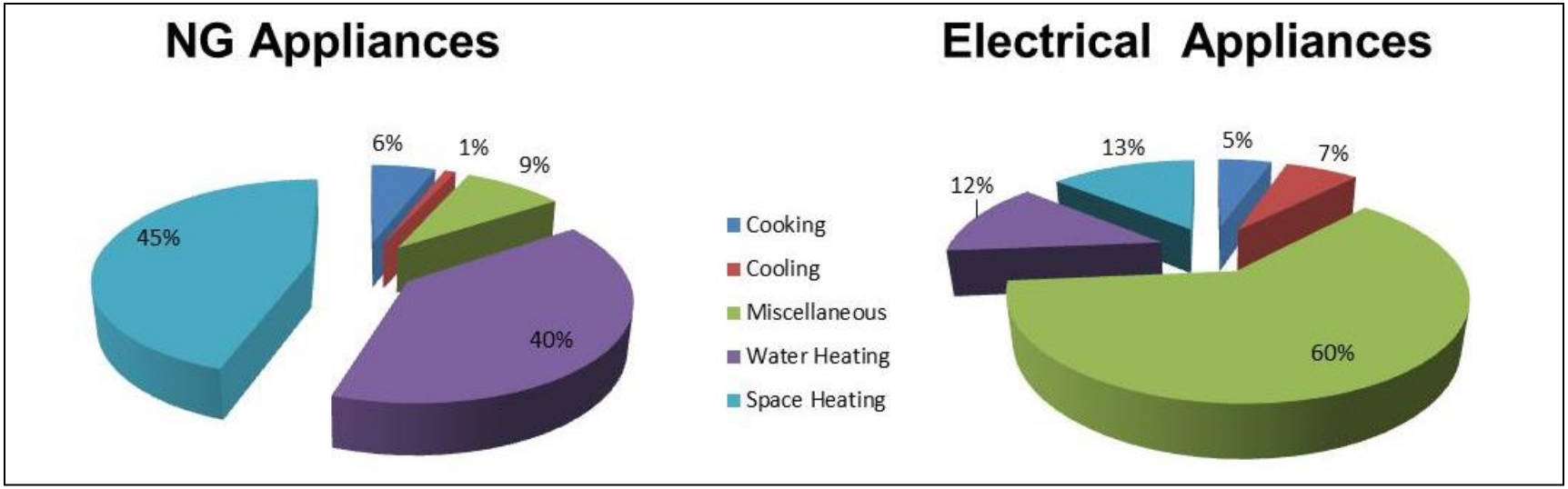
- Vacancy Rate
- Demolition Rate
- Retrofit Rate
- Floorspace Distribution
- End Use Appliance Efficiency
- ZNE
- End Use Appliance Demand Distribution

OUTPUT

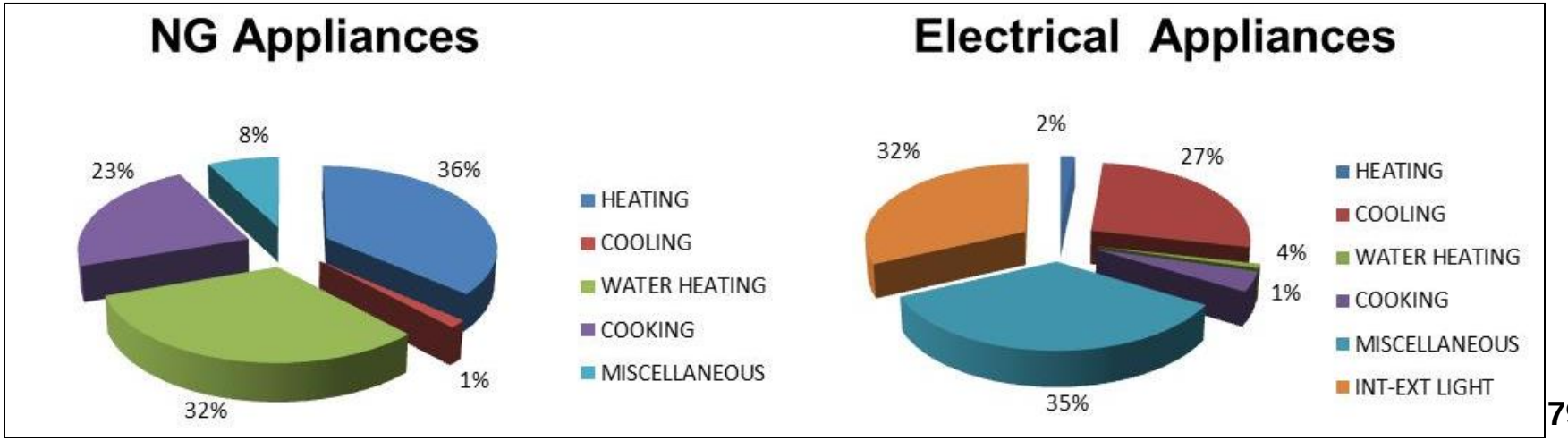
- Commercial Floorspace Projection
- Energy Demand per Building Type
- Criteria Emission Estimation

STATEWIDE ENERGY DEMAND BY SERVICE TYPE

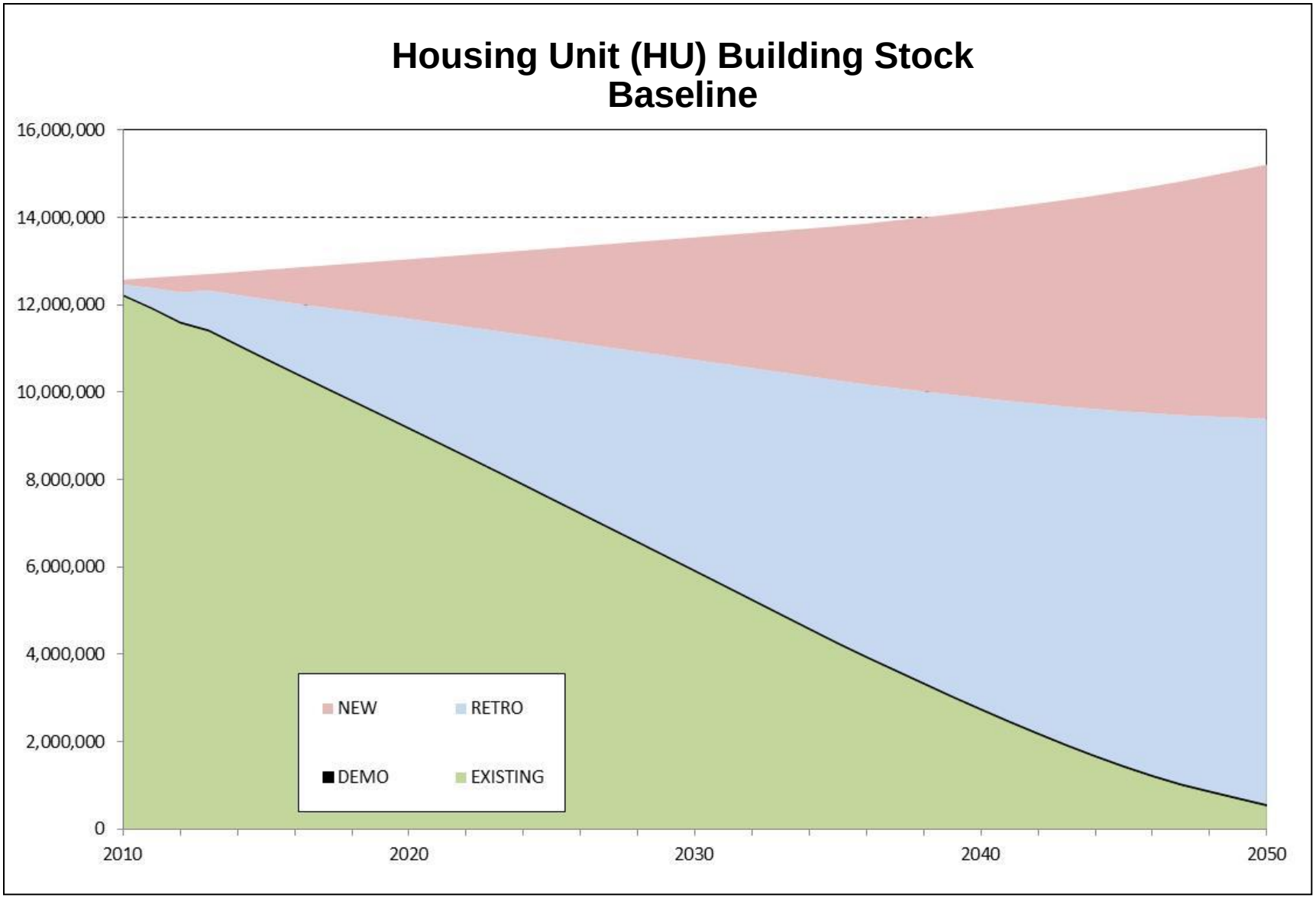
RESIDENTIAL



COMMERCIAL



RESIDENTIAL BLDG STOCK - STATEWIDE



VISION 2.0 NEXT STEPS

- Post model on public ARB website
- Develop scenarios for SIP and other programs
- Brief Board (fourth quarter 2015)