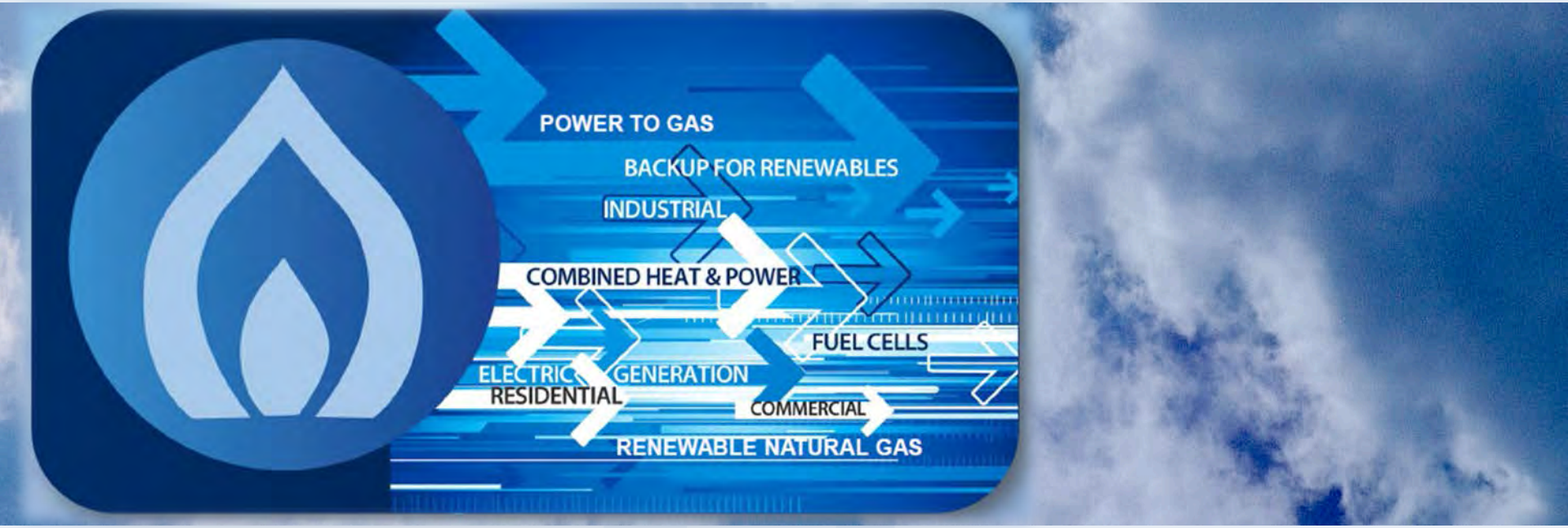

Natural Gas Pathways:

Towards a Clean and Renewable Energy Future for California

Southern California Gas Company
2016

SoCalGas A Sempra Energy utility

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California's Dual Emissions Challenge

Federal Clean Air Act and California Climate Change Initiative

FEDERAL CLEAN AIR ACT

Reduce SMOG by

50-60%

before the next 20 years

CA CLIMATE GOALS (AB32)

GOVERNOR'S EO:

By 2050, reduce GHG emissions to

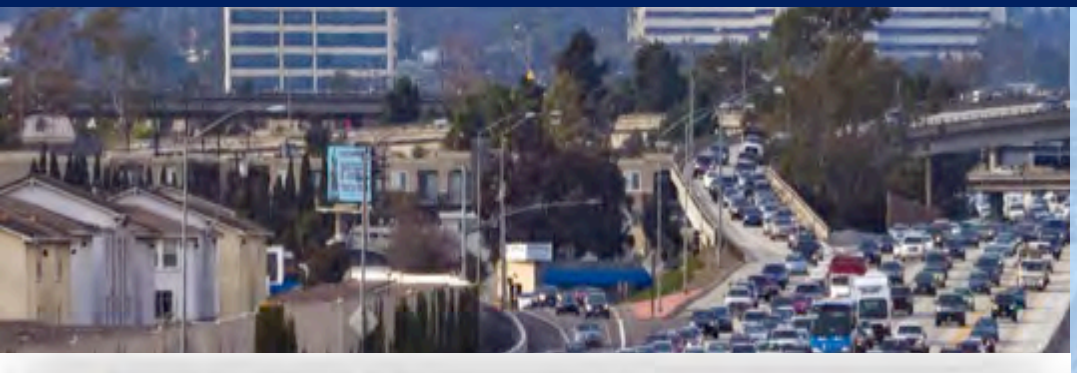
80% of 1990

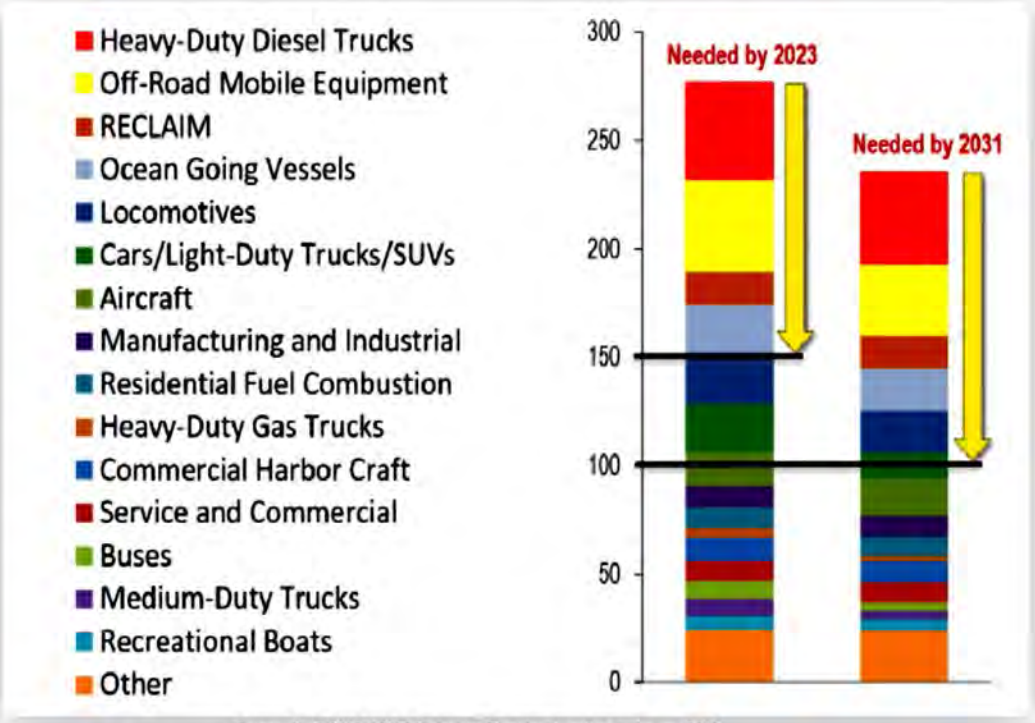
*Measures to Reduce Smog **and** GHG Emissions Drive Today's Energy and Environmental Agenda*

Natural Gas will Play an Increasing Role as a Solution

SoCalGas A Sempra Energy utility

We have a CLEAR FOCUS





Source: Draft 2016 AQMP Emissions Planning Inventory – January 2016

Major Ozone (NOx) Emissions Sources in South Coast Air Basin

THE TRANSPORTATION SECTOR

80%

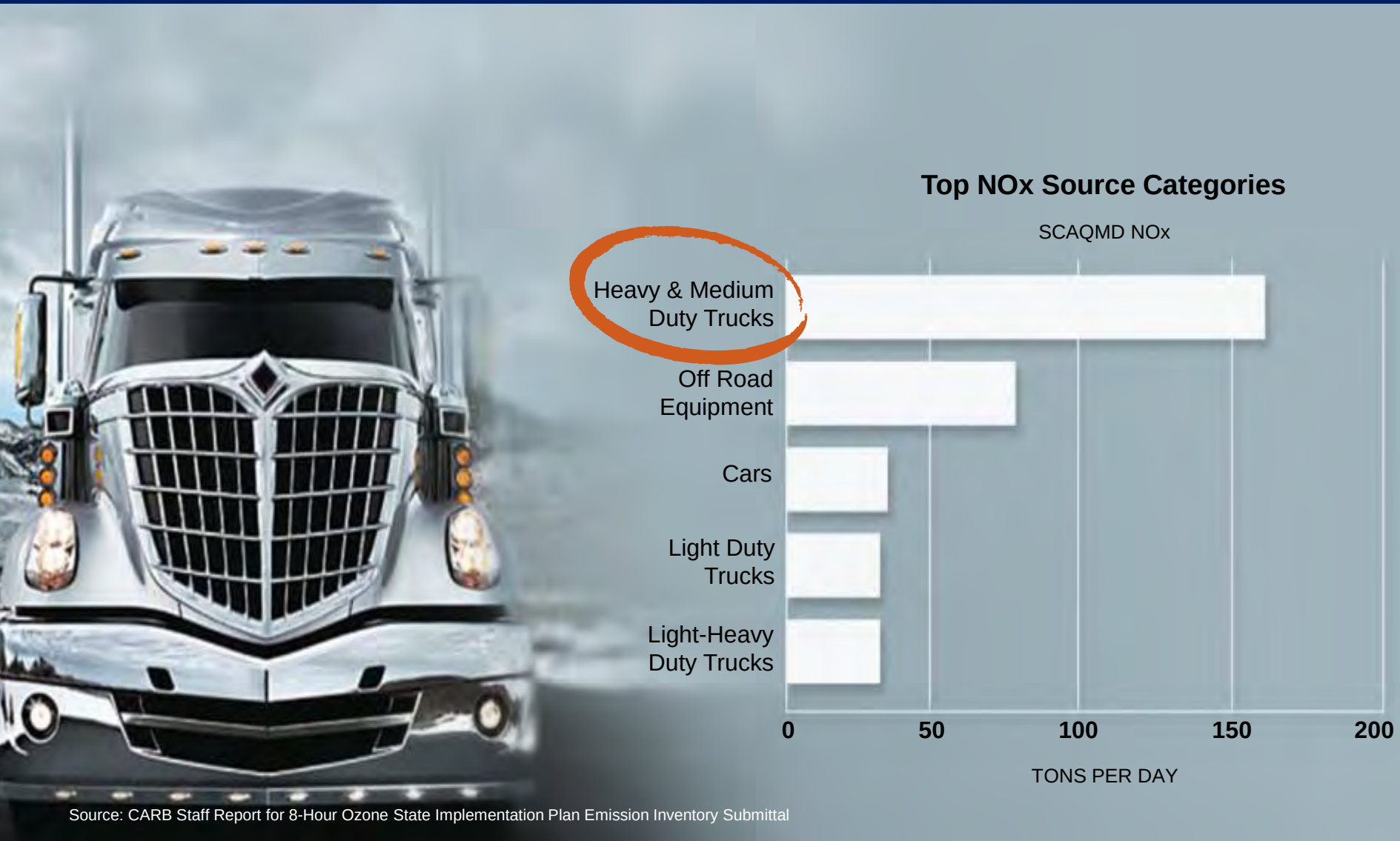
of the region's SMOG

Nearly 40%

of its GHG emissions

Start with the

BIGGEST POLLUTERS



Source: CARB Staff Report for 8-Hour Ozone State Implementation Plan Emission Inventory Submittal

NGV Game Changer:

NEW "NEAR-ZERO" TRUCK ENGINE TO BE *READY FOR PRIME TIME*

Near-Zero Emissions Natural Gas Engine

<0.02 g NOx

90% NOx reduction

Renewable Natural Gas as Transportation Fuel

> 80% GHG reduction

- Heavy Duty truck engine with 90% lower NOx emissions ***TODAY***
- Tailpipe emissions are the same as emissions from generating electricity to run a similar electric truck
- For Goods Movement, this truck will meet California's ambitious 2050 targets ***decades before*** any other technology
- RNG already delivering greatest GHG reductions from diesel ***TODAY?***

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Technology Transfer
and Transportation Pathways

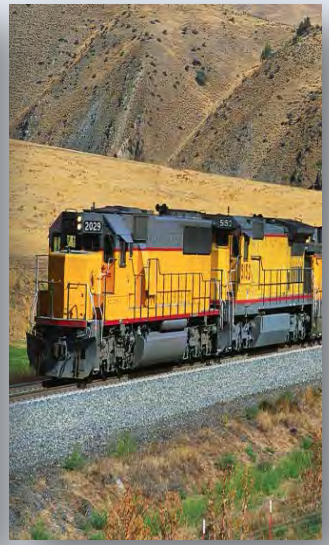
SoCalGas' Transportation Pathway focuses on natural gas vehicles in heavy duty sectors, which represent the largest share of both ozone/greenhouse gas problem. Technology transferrable to other sectors:

Current Focus | **Expanding Focus**

Transit/Fleet Vehicles

Heavy Duty Trucks Short/Long Haul

Off-road High Horsepower/ Construction Equipment



Locomotives Short/Long Haul

Marine Vessels

CNG ⟷ **LNG**

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OGV Sector is Signalling for LNG Infrastructure

- 63 LNG vessels in operation worldwide and increasing
- 76 LNG vessels on order worldwide and increasing
- Multiple recent trade journal announcements of new LNG vessels under contract at shipyards, e.g. July 2015
  - 20 LNG-ready Valemax ore carriers on order
  - $2.3bn Company, Exmar LNG, created; one-stop shop along the LNG value chain integrating liquefaction, shipping and regasification assets
- IMO-required reduction of bunker fuel sulfur content is the predominant global driver of LNG adoption

"I think the early adopters can drive forward LNG infrastructure…" Roger Frizzell, Carnival Cruise, June 18, 2015

Opportunity to Collaborate with Railroads

- Class 1 Railroad companies are currently evaluating NG fuelling economics & logistics
- If decision is made, most likely NG scenario would be to deploy transcontinentally on a line-by-line basis.
- NG bunkering availability could affect decision to switch and could attract early NG conversion of Southern California lines
- Conversion of these lines could bring a higher proportion of Tier 4 locomotives to the region

California is Planning to Meet Criteria Pollutant Goals: HEAVY-DUTY VEHICLE SECTOR

CARB Mobile Source Strategy follows a low NOx path for heavy-duty trucks from 2015 to 2030

"In contrast, deployment of 350,000 electric trucks over the next 15 years would require technology development and cost that are well beyond what will be needed to deploy low-NOx trucks."

SCAQMD calls for near zero emission heavy-duty vehicles

"In Southern California, clean, zero- and near-zero emission vehicle technologies are critical to meeting clean air standards. Cummins Westport's new engine provides an important tool toward reaching that goal."

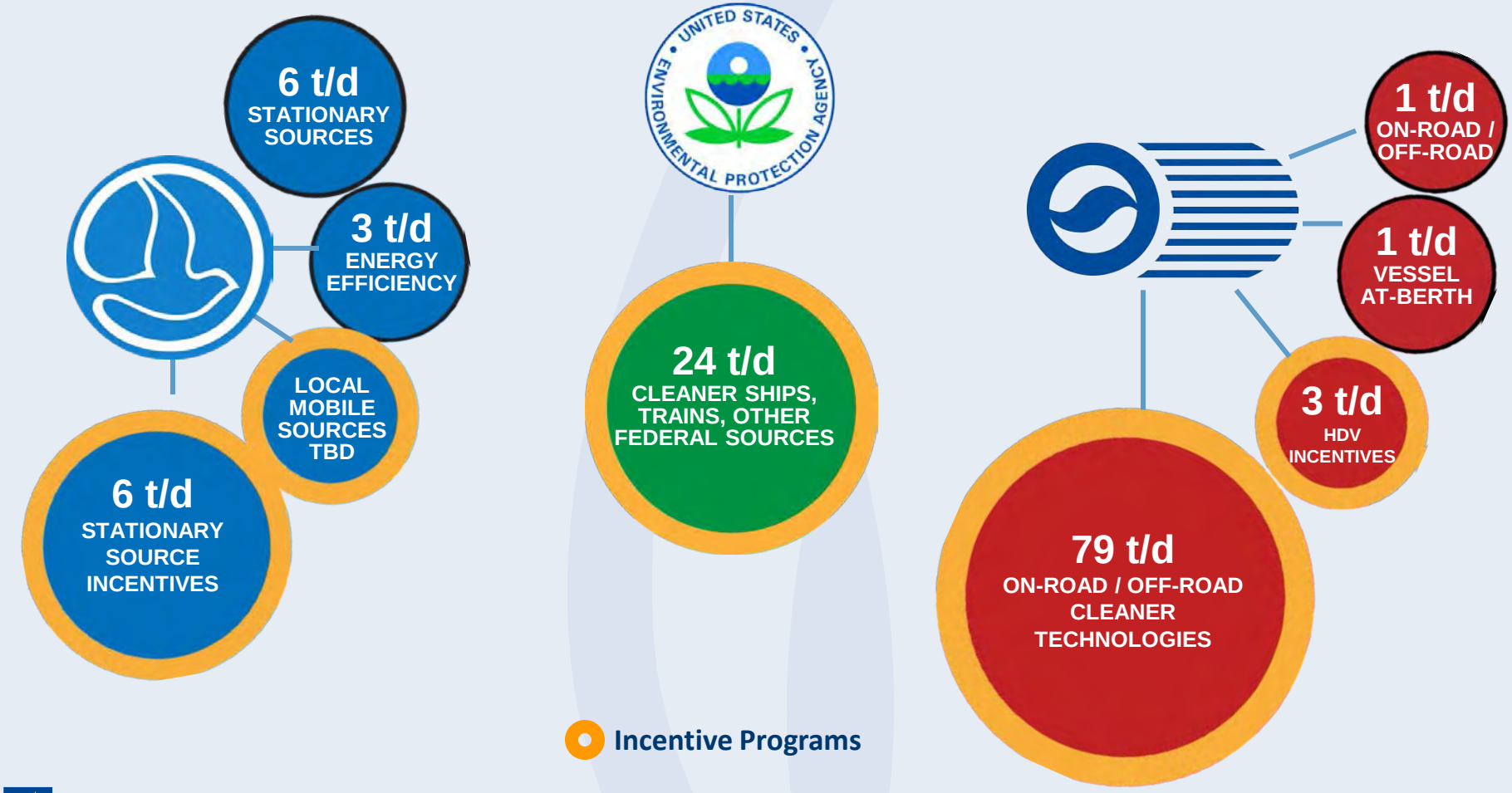
SJVAPCD adopted an action plan promoting deployment of natural gas vehicles and infrastructure

"Heavy-duty natural gas vehicles provide fewer barriers to adoption than electric/hybrid."

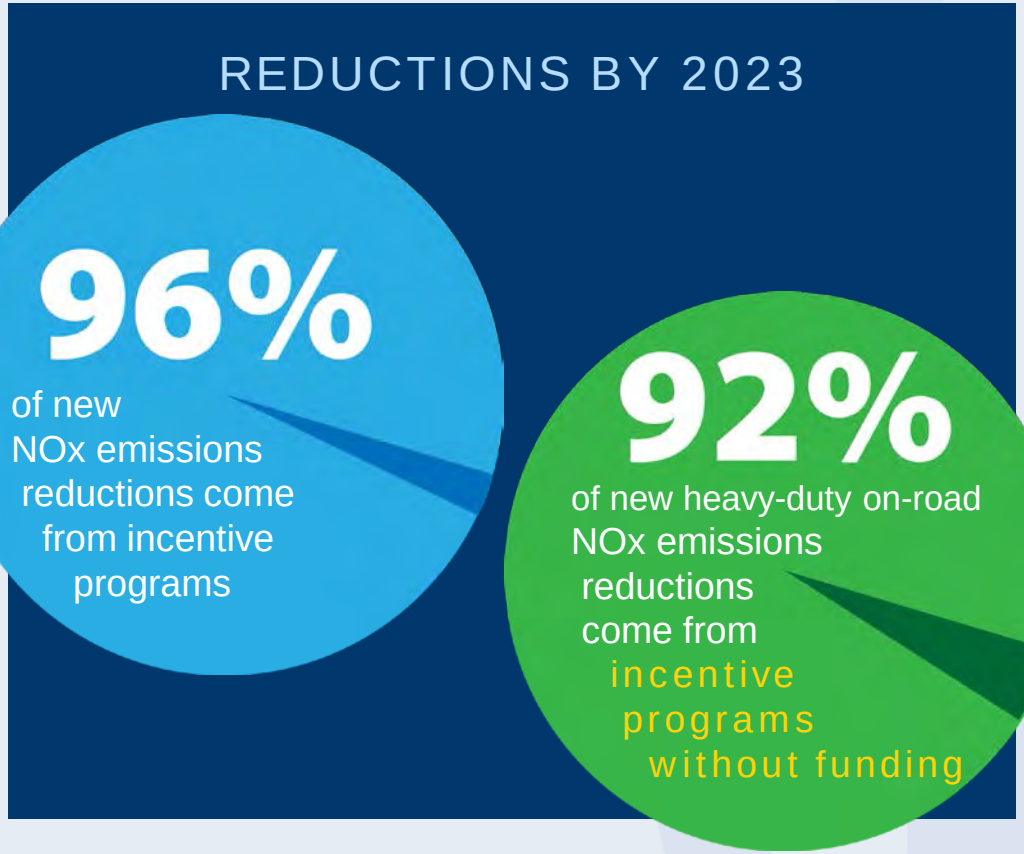
AQMP Relies on Incentives for 85%

of All Emissions Reductions Needed by 2023:

SCAQMD CURRENT SIP/AQMP "FAIR SHARE" STRATEGY FOR 80 PPB



CARB Mobile Source Strategy -- Relies on Incentive Programs: HEAVY-DUTY VEHICLE SECTOR



- The "centerpiece" of the mobile source strategy, a federal HD standard of 0.02 g/brake hp-hr., will not start until 2023
- Incentives must be used prior to 2023

SoCalGas Incentives Study (2015)
-- Potential for Significant NOx Reductions

Natural Gas in Heavy Duty Transportation Sector Can Deliver:

33% NOx reduction (17 TPD) by 2023

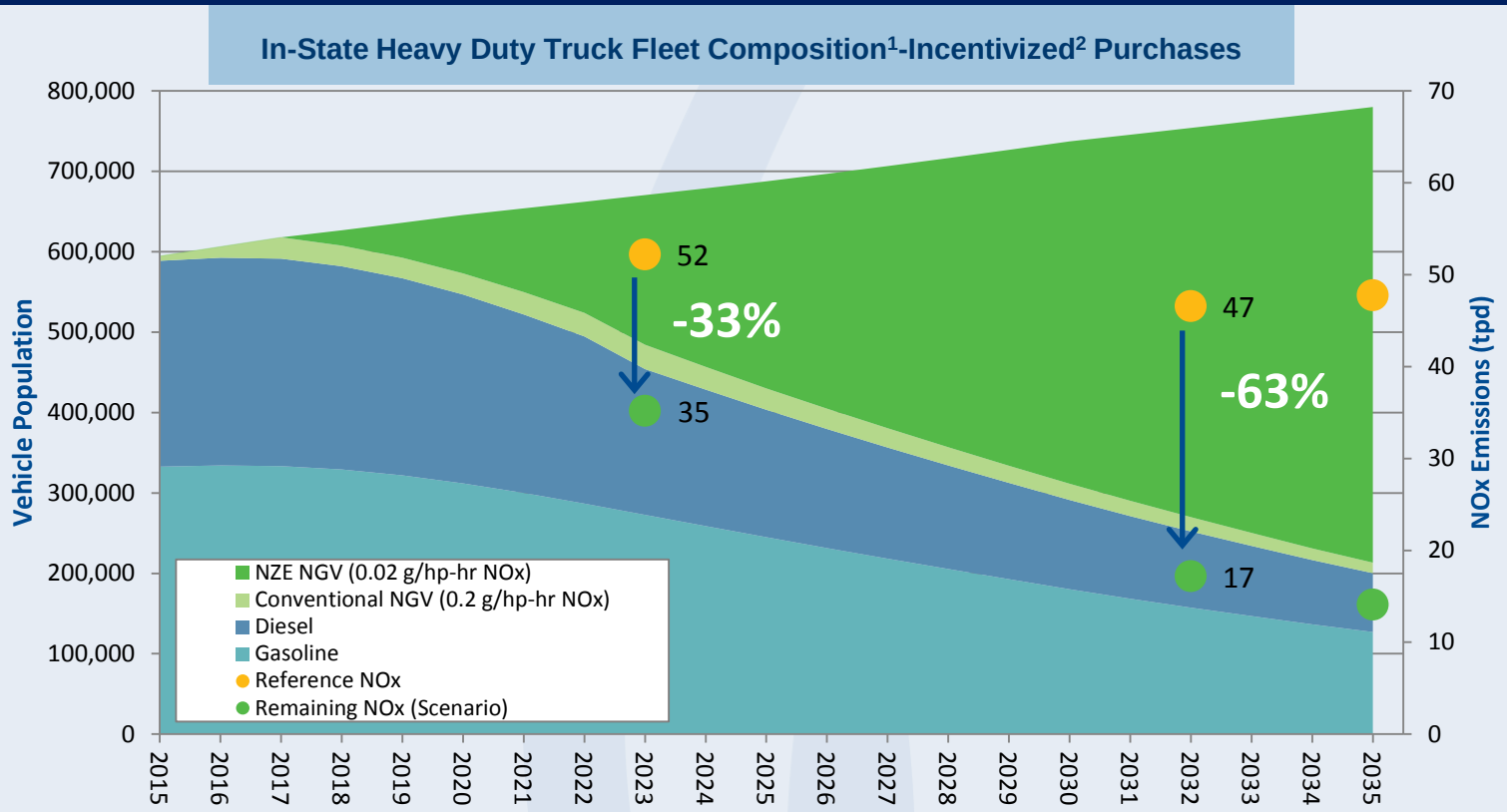
Econometric Modeling (NPC Model) Strategy

- Fuel price savings drive natural gas technology adoption by the heavy-duty trucking sector.
- Financial incentives ($15-30K/vehicle) can *accelerate and increase* the adoption of conventional natural gas technologies, helping air districts (especially South Coast and San Joaquin Valley) meet ozone deadlines.
- Additional financial incentives (<$10K/vehicle) can shift conventional natural gas technology purchases to "NZE" natural gas purchases, maximizing NOx reductions.
- For LA area, NZE incentive period (2018-2023) can deliver 33% NOx reduction (17 TPD) by 2023. Continued NZE adoption program can deliver a 63% reduction (30 TPD) by 2032 in LA area.

Incentives for Near-Zero Emissions

Heavy-Duty Trucks Can Deliver

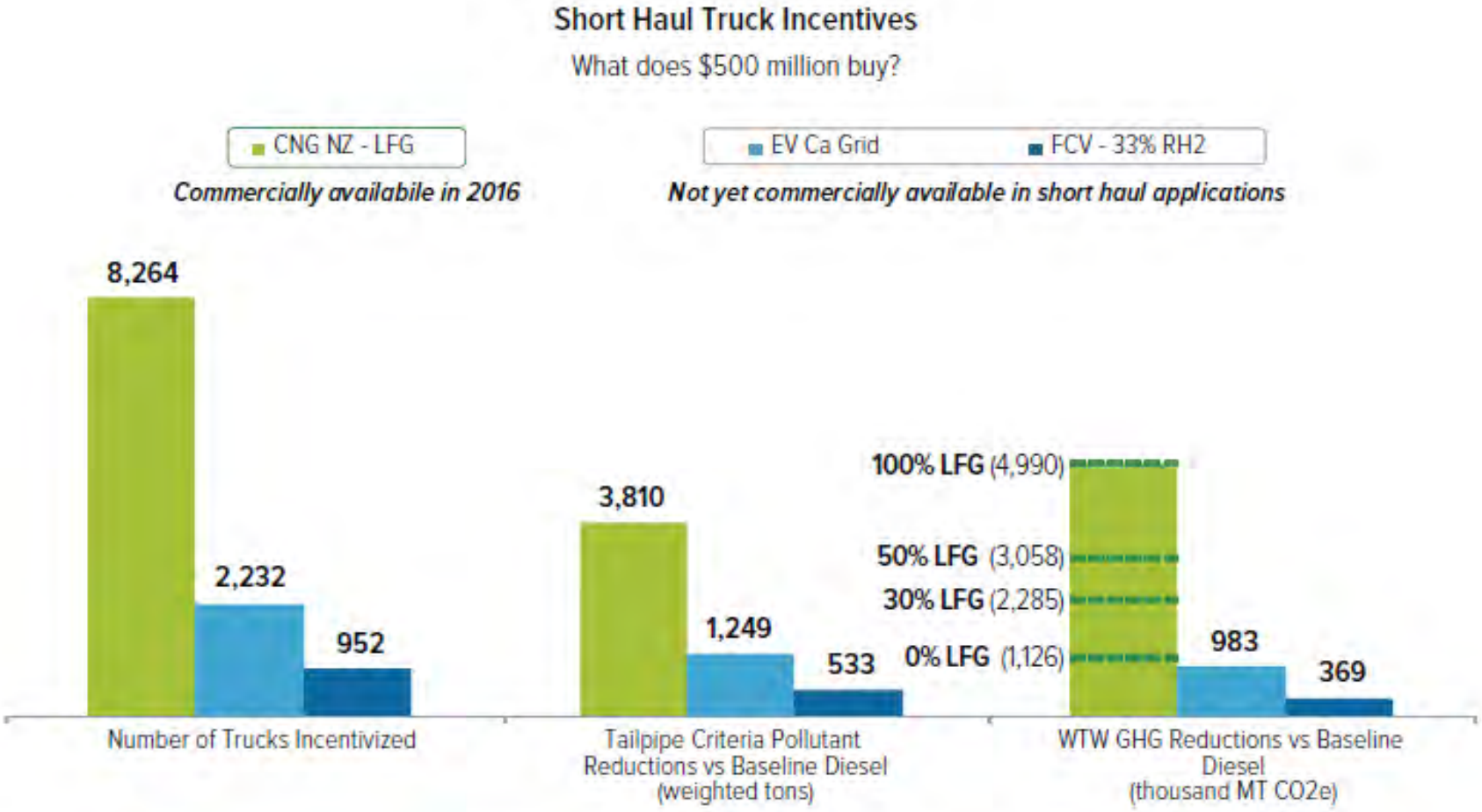
Substantial Emission Reductions



Note:

1. Analysis includes T7 Drayage, T7 Single, T7 Solid Waste Collection Vehicle, T7 Tractor, T7 Tractor Construction, T7 Agriculture, T7 Single Construction, T7 Public, T7 Utility, T7 IS, T6 Instate Heavy, T6 Instate Small, T6 Utility, T6 Public, T6 TS, T6 Agriculture, T6 Instate Construction Heavy, T6 Instate Construction Small, LHDDT, and LHDGT.
2. Maximum incentives range from $15,500 - $35,000/Truck depending on the vehicle type and engine size
3. Assumed penetration rates after the incentive period ends remain at the 2023 level due to further regulatory or other mechanism

Comparison of Truck Deployment and Benefit ($500 million investment)

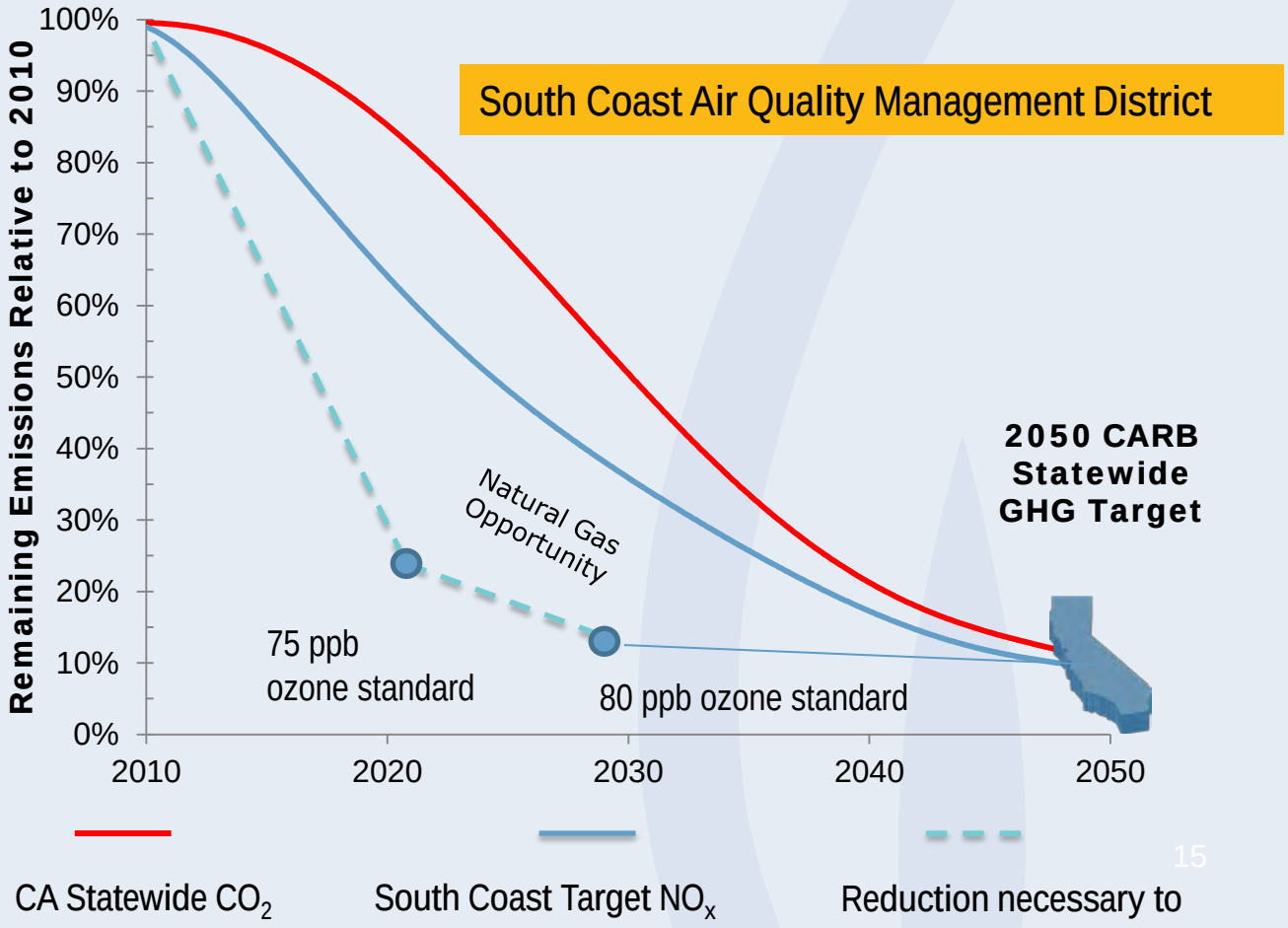


Incentive amounts based on incremental purchase cost of advanced heavy-duty short haul trucks over baseline diesel truck
Based on emissions and vehicle activity data from CARB EMFAC 2014
Weighted emissions = NOx + 20*PM10 + ROG
GHG emissions based on illustrative fuel pathways calculated by ARB Staff using CA-GREET 2.0
Cost effectiveness uses Moyer program capital recover factors based on typical retention period of first owner

Source: "Game Changer Technical Report," Figure 4, May 2016

Current State GHG Pathway -- Focused on Electrification

Will Miss Ozone Deadlines



Reductions need to be achieved *Faster* & *Sooner* than current statewide GHG reduction goals

Use of Natural Gas in Transportation Sector can help *achieve* ozone standard sooner

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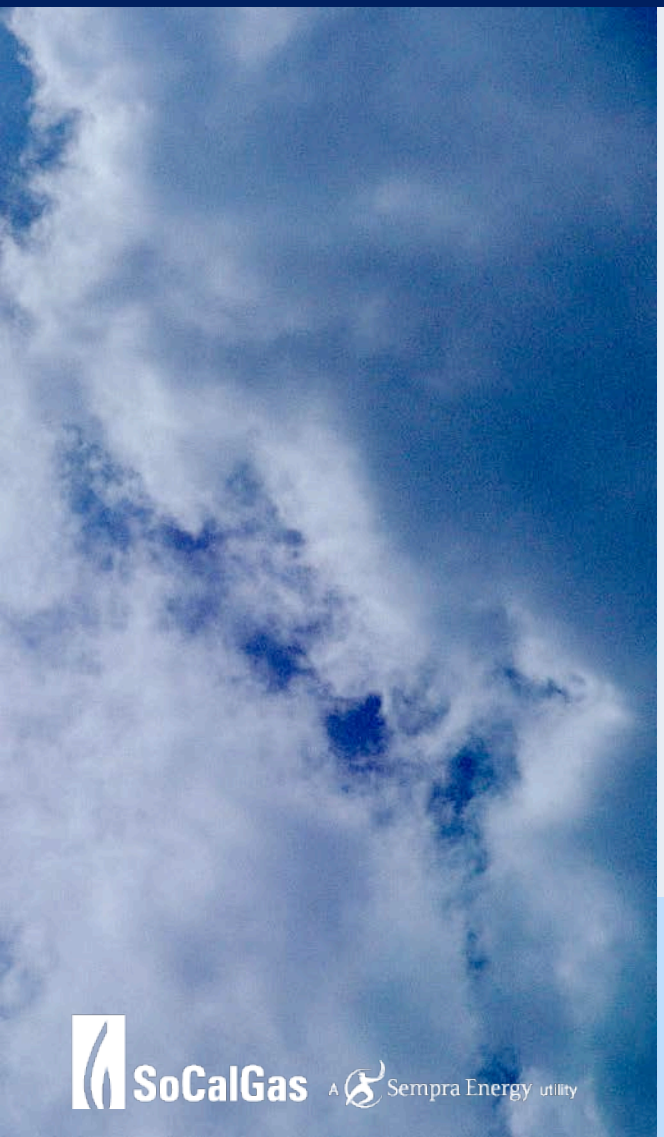
California Climate Change Policy

Make Room for "Near-Zero" End Uses and Low Carbon Gas



California focused on electrifying end uses; and "de-carbonizing" electricity

- Electrify energy end uses
- Electrify transportation
- De-carbonize generation

SoCalGas focused on "near-zero" end use technology -- "electric equivalent" ; and "de-carbonizing" the pipeline

- Near-zero gas technology
- Near-zero NGV's
- Decarbonize gas supply
  - Hydrogen blending
  - Renewable methane feedstocks

It's *NOT* Either/Or.

It's ***BOTH***!

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De-Carbonizing Electricity:

Natural Gas Stationary Use Pathways

The move toward “near-zero” emission technology focuses on:

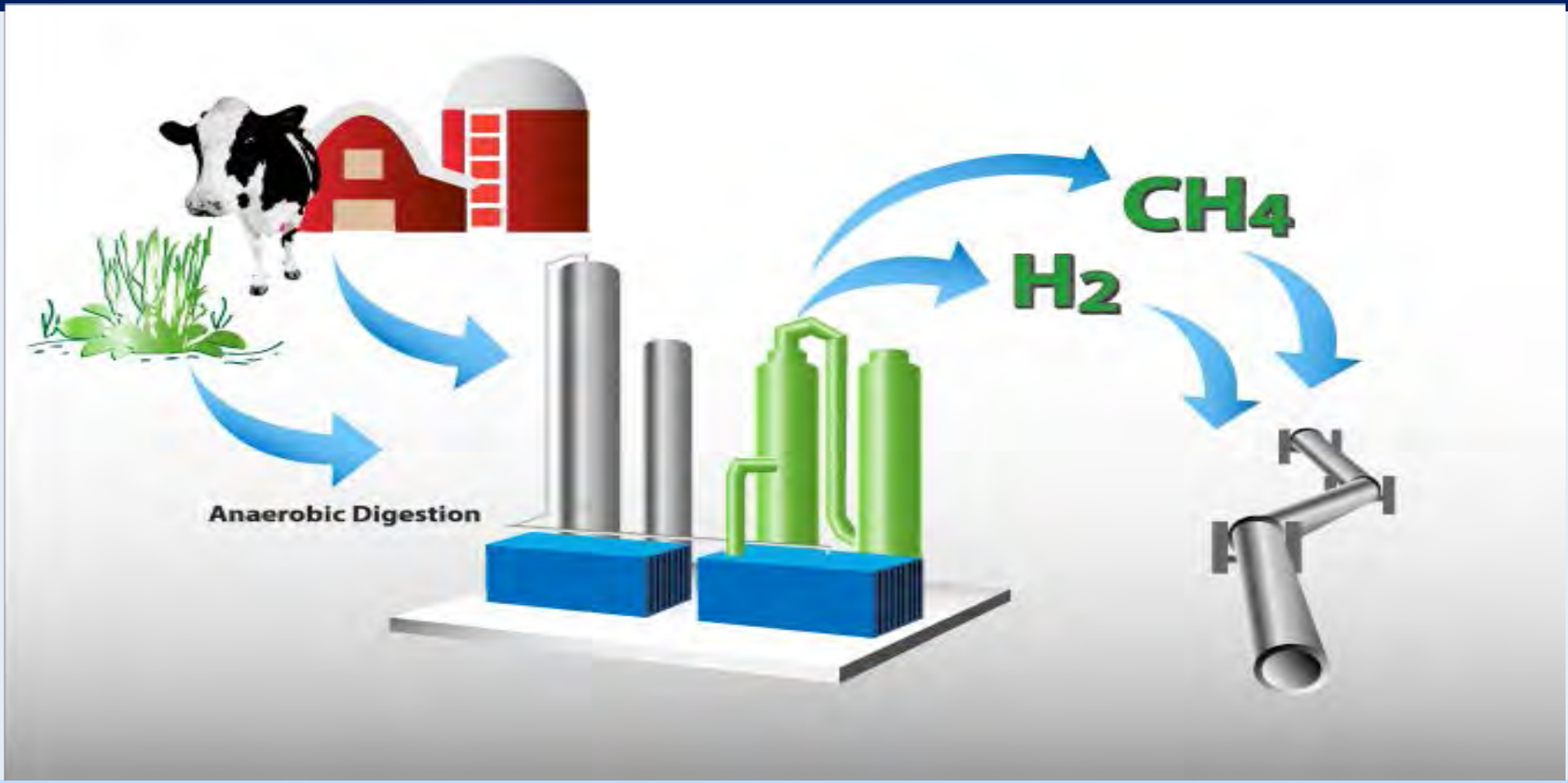
- Distributed Generation
- Small-scale, Fast-ramping Generation Matched with Renewables
- Power Generation with Carbon Capture

Not just Solar and Wind...

- Fuel Cells
- Micro-turbines
- Combined Heat & Power

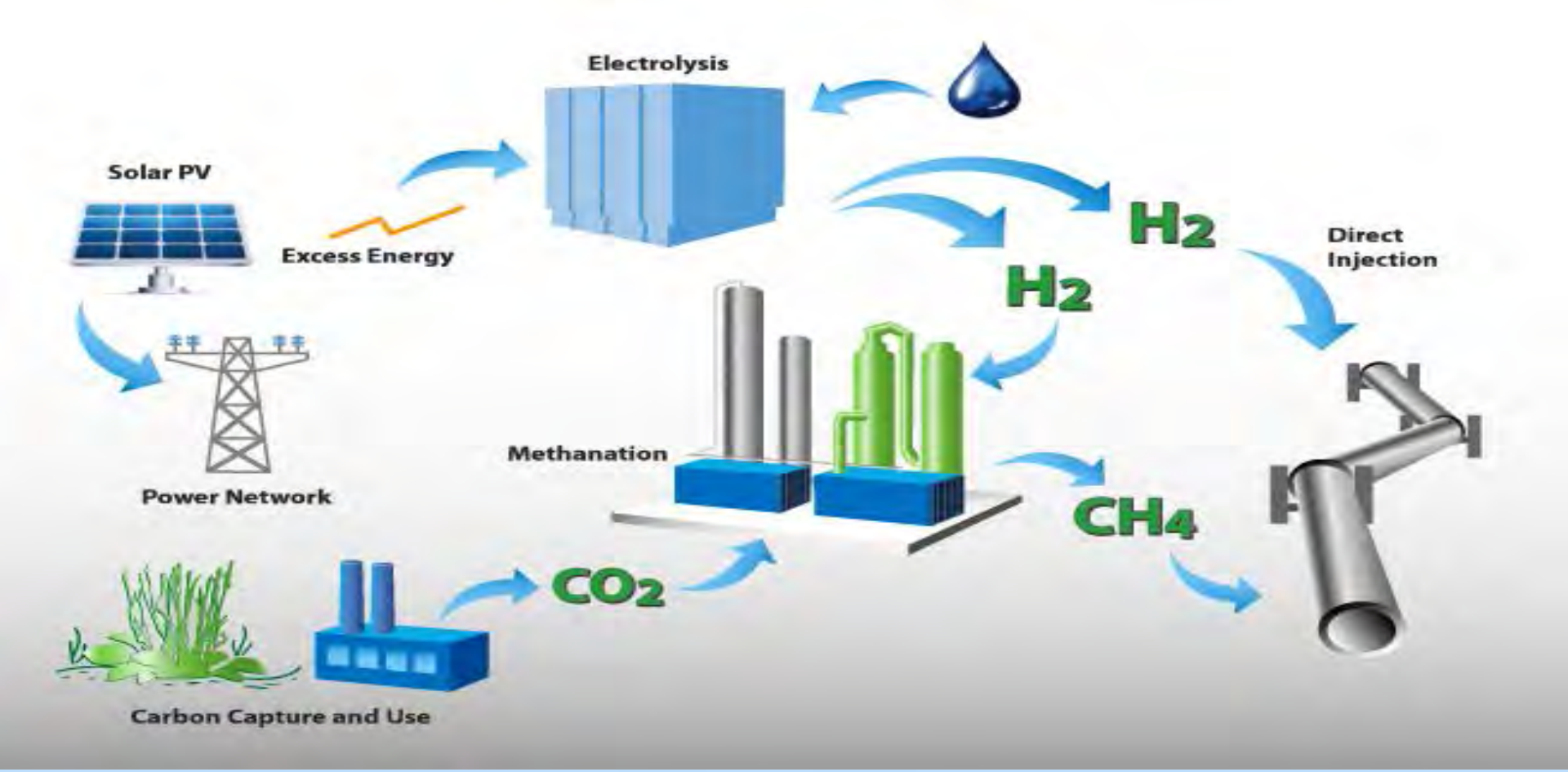
De-Carbonizing the Pipeline:

Waste or Biomass To Hydrogen or Biomethane



De-Carbonizing the Pipeline:

Electrolysis of Excess Renewable Electricity (Power-to-Gas)



Power-to-Gas Projects:

Provides green hydrogen pathway and grid storage

2MW Power-to-Gas Demonstration Plant (Falkenhagen, Germany)

- **First power-to-gas plant to inject hydrogen into the natural gas grid (August 2013)**

Hydrogenics Plant (Stuttgart, Germany)

- **Uses a PEM electrolyzer to produce H_2 from water. Uses CO2 from biogas plant. Injects CH_4 in pipeline system**

30 projects launched in Europe to date

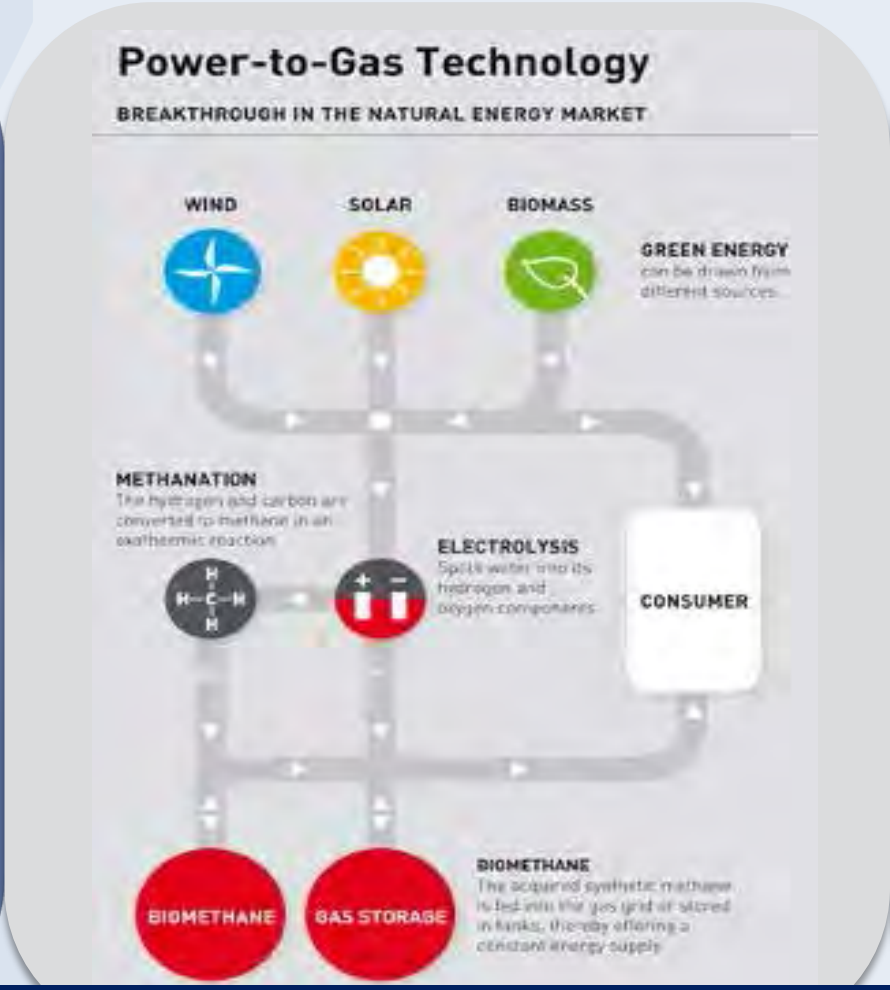
German Energy Agency
on Power-to-Gas: *"System Solution"*

- **DENA Website (German Energy Agency)**

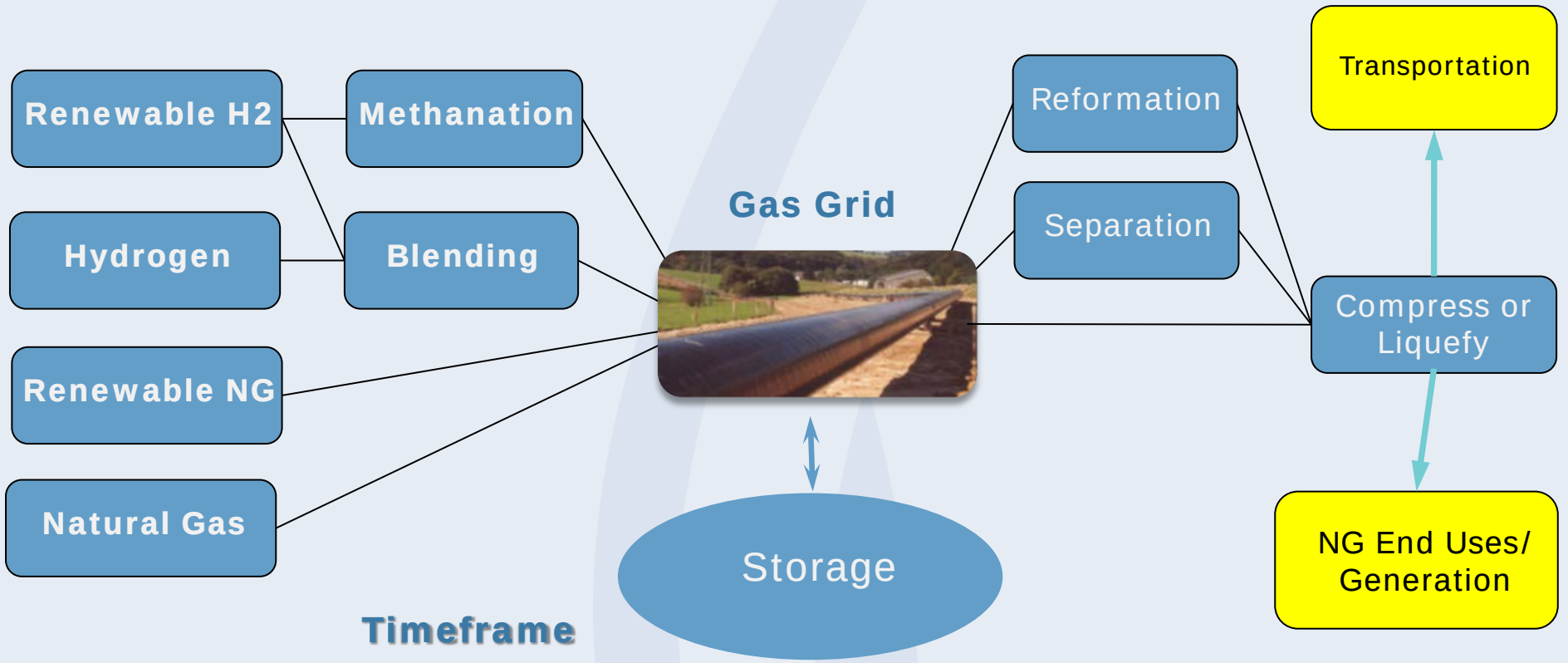
  With the Power-to-Gas Strategy Platform, the Deutsche Energie-Agentur GmbH (dena) – the German Energy Agency – and its partners are supporting the use and development of the *Power-to-Gas system solution.*

- **CAISO (on the "Duck Curve")**

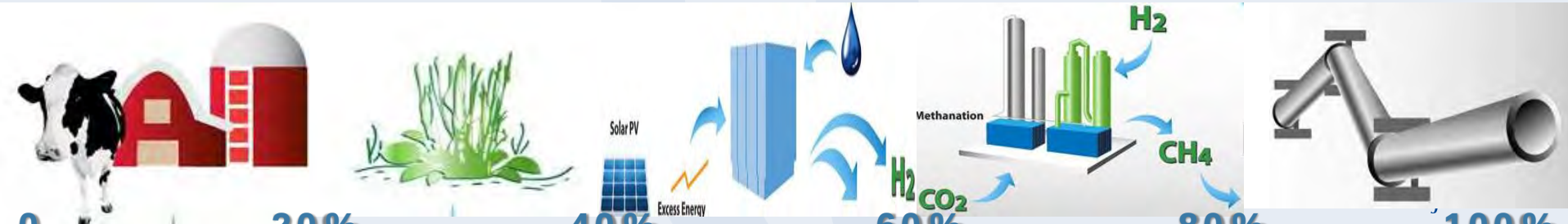
  …steps must be taken to mitigate over generation risk. These steps include increasing exports…and requiring renewable generation curtailment. The ability to export power depends on the needs of neighboring entities…the resource mix would also benefit from resources with energy storage capabilities…



Existing Infrastructure Can Serve
Multiple Low Carbon Gas Pathways



Timeframe



0 20% 40% 60% 80% 100%

E3 Study:
Integration of New Low/Zero Carbon Options

Energy+Environmental Economics

Strategic use of gaseous fuels supports near- and long-term goals

- In nearer term, opportunities for efficiency, “near zero” technology and new uses for natural gas (transportation)
- In medium- to long-term, new low-carbon sources of gas need development and introduction

- **Pipeline de-carbonization works together with electrification towards Climate Change objectives**
- **Pipeline de-carbonization offers Cost Effective and Resilient Pathways**
- **De-carbonization can play an important role Integrating Variable Renewable Generation Resources**
- **Pipeline de-carbonization reduces emissions in sectors that are otherwise difficult to electrify, including heavy duty vehicles; residential and commercial end uses, and industrial end uses**
- **Managing “Energy Grid” (gas and electric together) = efficiency and cost avoidance**

SoCalGas Facilitating Cleaner Energy

Options for Our Customers

- **RD&D** of cleaner, more efficient **natural gas technologies, inc. P2G at UC Irvine.**
- New State **Natural Gas Utilization Policy**
- Offering **Compression Services** to facilitate development of NGV market
- Offering **Biogas Conditioning Services** to facilitate development of renewable natural gas market
- Offering **Distributed Energy Services** tariff to facilitate more efficient use of heat and power
- Considering **LNG, RNG and P2G** projects

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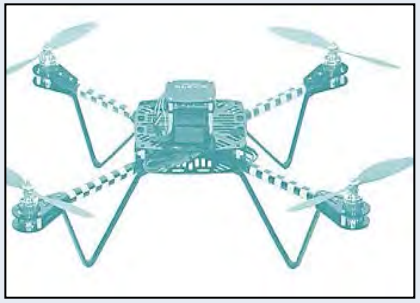
SCG: Sensible Policies & Regulations



- **Set emissions standards / avoid technology mandates**
- **Improve balance between short- and mid-term NOx reduction and long-term GHG reduction goals**
  - Technology availability and time urgency
  - Natural Gas for transportation
  - RNG market development (biomethane) and deployment
- **Support deployment for natural gas pathway technologies**
  - Transportation deployment funding
  - Utility role in refueling infrastructure/joint refueling (CNG/H2/Elec)
  - Intermodal fueling strategy (ports, rail, goods movement)
  - Distributed gas generation (CHP, fuel cells, microturbines)
  - Power-to-gas development and green hydrogen technology
- **Support R&D; and methane mitigation**
  - R&D funding (HD transportation, DG, RNG, P2G)
  - Low-emission connections and fittings
  - In-home sensing technologies
  - Commercial/industrial leak monitoring

The Path is Clear

We Need to Invest

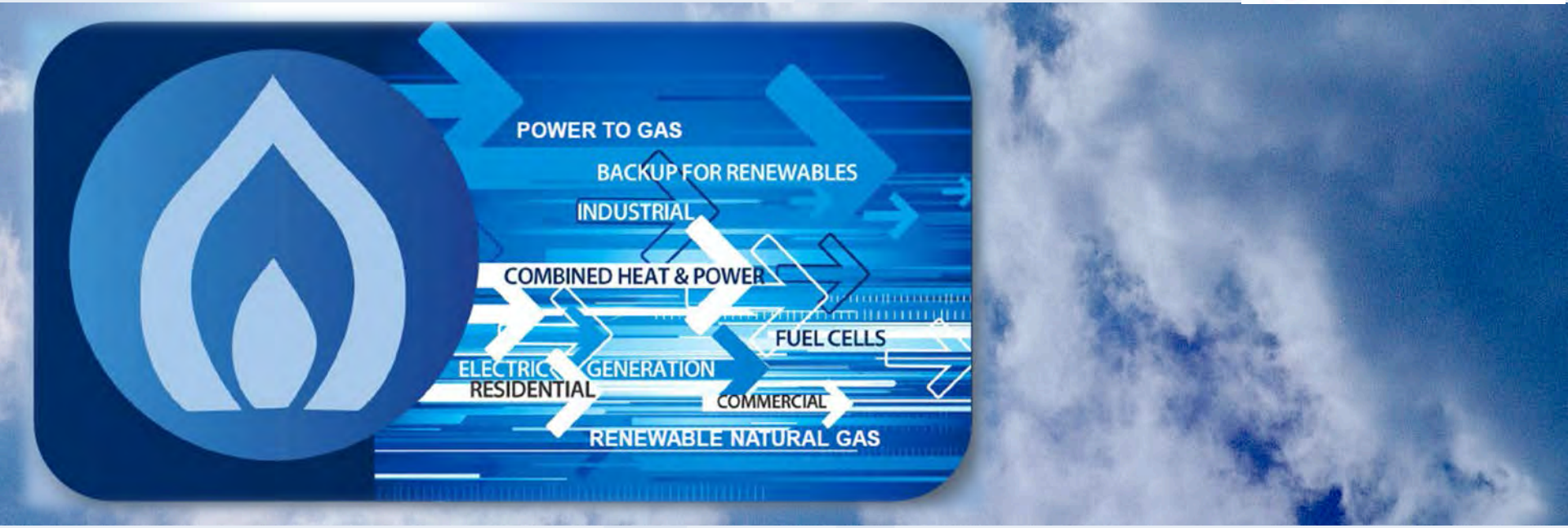
Reduce SMOG through Transportation sector

Decarbonize Electricity – Distributed Generation

Decarbonize Natural Gas – Biogas

Decarbonize Gas and Electricity – Power-to-Gas (P2G)

NEAR TERM within 5 years	MID-TERM Within NEXT 10 years	LONG TERM within NEXT 20 years
90% NOx reduction from "near zero" engines	Trucking & Transit conversions Rail conversions	Marine conversion
Combined Heat & Power	Fuel Cells & Microturbines	
	Low carbon gas supply from renewable sources using existing waste streams	Additional gas supply from purpose grown crops and solar
	Market development of P2G systems for vehicle fuel and grid support	P2G enables renewable enegy storage in gas pipeline system



THANK YOU!

External Affairs and Environmental Strategy
2016

Background Slides
(E-3 Update)

E-3 2030 Update: Three Scenarios Evaluated

1. Low Carbon Gas Scenario (meets 2030, 2050 GHG targets)
   - Uses renewable gas in buildings, no building retrofits or building electrification required
   - Uses Renewable CNG in medium and heavy duty vehicles, along with hydrogen fuel cell and electricity for medium duty vehicles
   - High renewables; electric and fuel cell light-duty vehicles
2. Electrification Scenario (meets 2030, 2050 GHG targets)
   - High building electrification, retrofits to all-electric buildings
   - Uses hydrogen fuel cell, electricity and renewable diesel for medium and heavy duty vehicles
   - High renewables; electric and fuel cell light-duty vehicles
3. Reference Scenario: reflects 2020 GHG policies only

E3 Low Carbon Gas Study

Key Scenario Characteristics

	2015	2030 Electrification	2030 Low Carbon Gas
Renewables (% of retail sales)	27%	60%	60%
ZEVs* (millions of vehicles)	0.1	9.4	9.3
CNG and LNG Vehicles (millions)	0.03	0.31	0.36
Flexible Loads (MW, implied downward capacity)	0	3,662	3,527
Energy Efficiency in Buildings (% reduction in final energy demand relative to reference)	N/A	18%	11%
Residential Electric Space Heating, Water Heating, and Cooking (% of buildings)	19%	52%	19%
Commercial Electric Space Heating, Water Heating, and Cooking (% of energy usage)	13%	41%	8%
Biogas (% of total gas demand)**	0%	2%	33%
Renewable Diesel (% of total diesel demand)	2%***	85%	2%
Statewide GHG Reduction (% Reduction from 1990 Levels)	2%	**40%**	**40%**

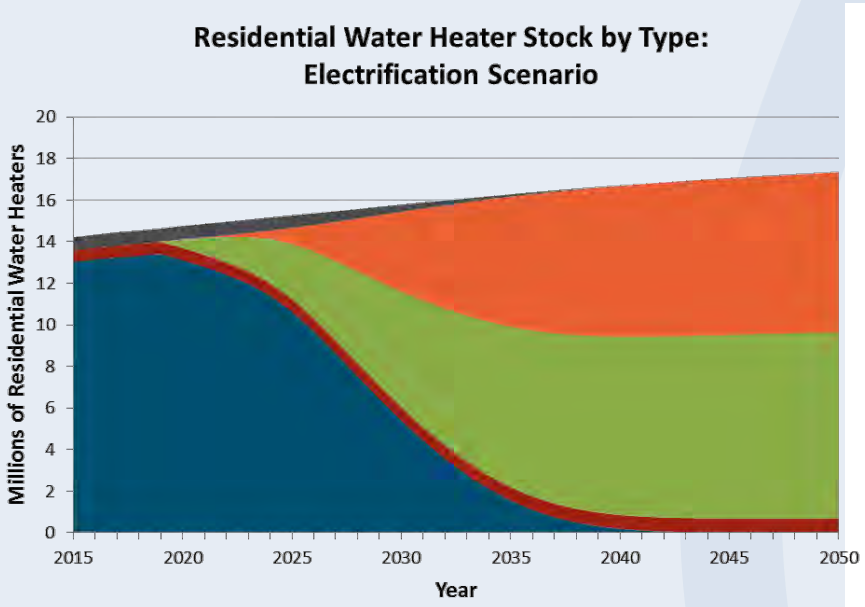
*Includes BEVs, PHEVs, and FCVs

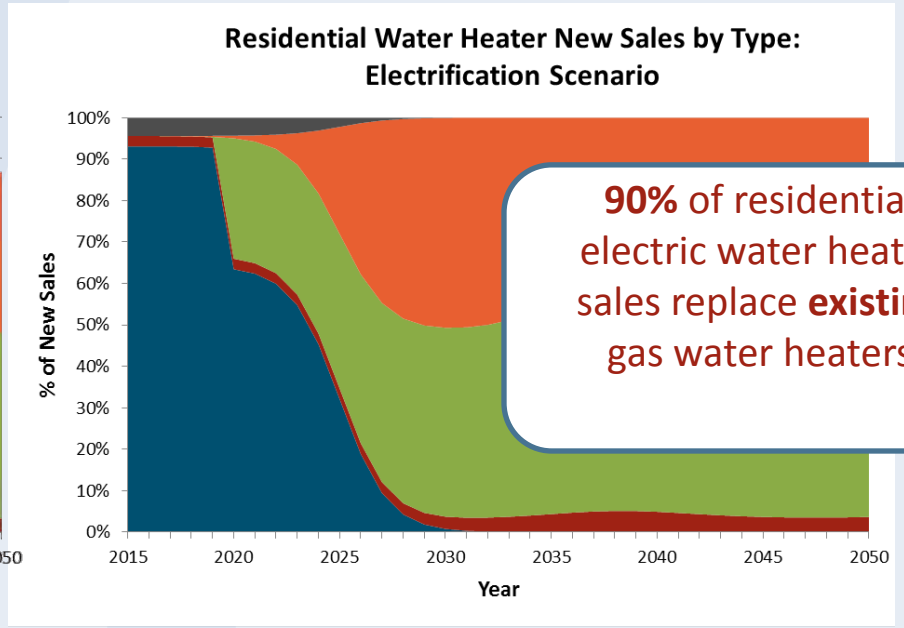
** Biogas is directed to non-EG customers only; biogas is not used by electric generators

***Estimated renewable diesel share in 2013, based on reported LCFS compliance

Electrification Scenario Involves Extensive Building Retrofits

» The Electrification Scenario: By 2030, 98% of new sales of residential water heaters are electric. 90% of new electric water heater sales are for retrofits in existing buildings, 10% are installed in new construction.

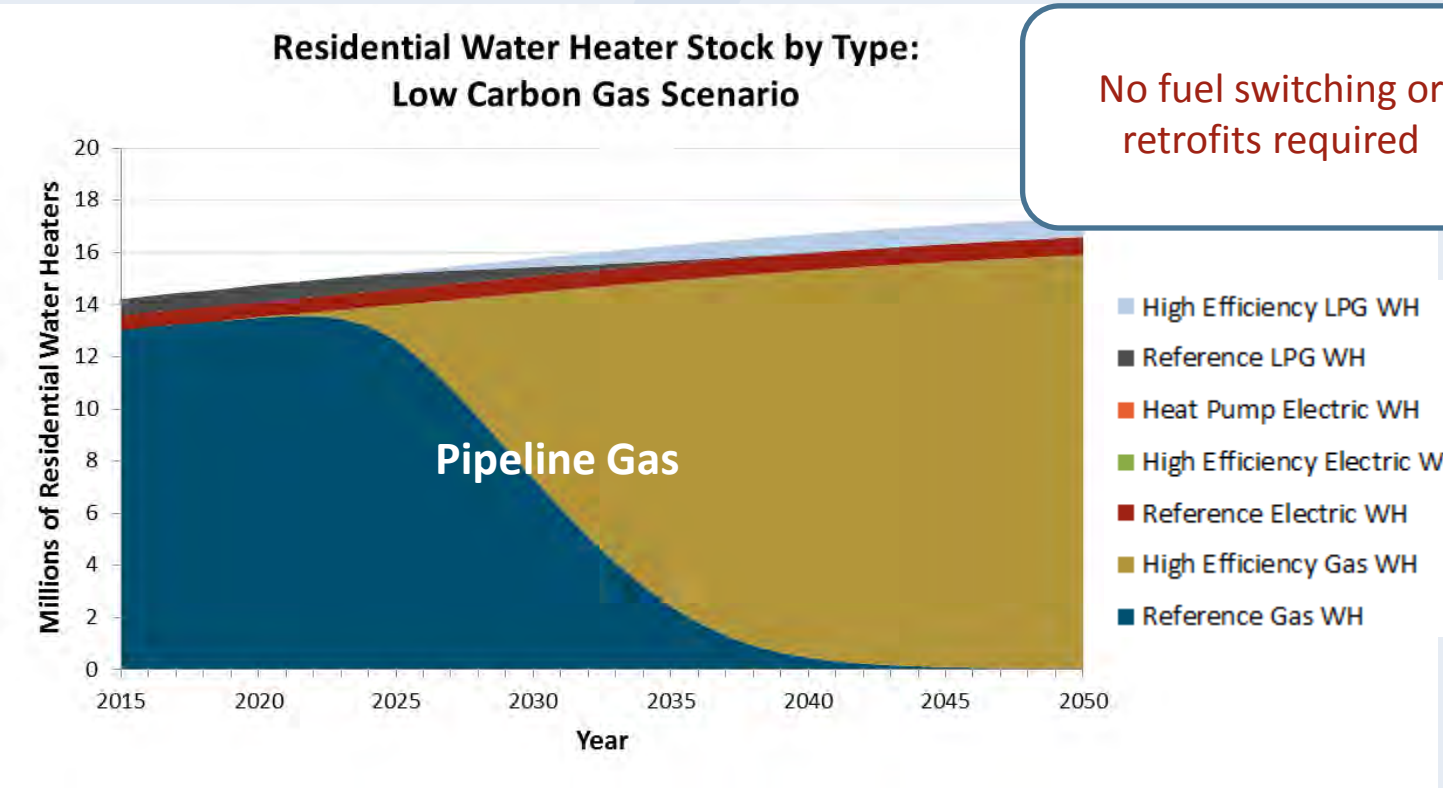




90% of residential electric water heater sales replace **existing** gas water heaters

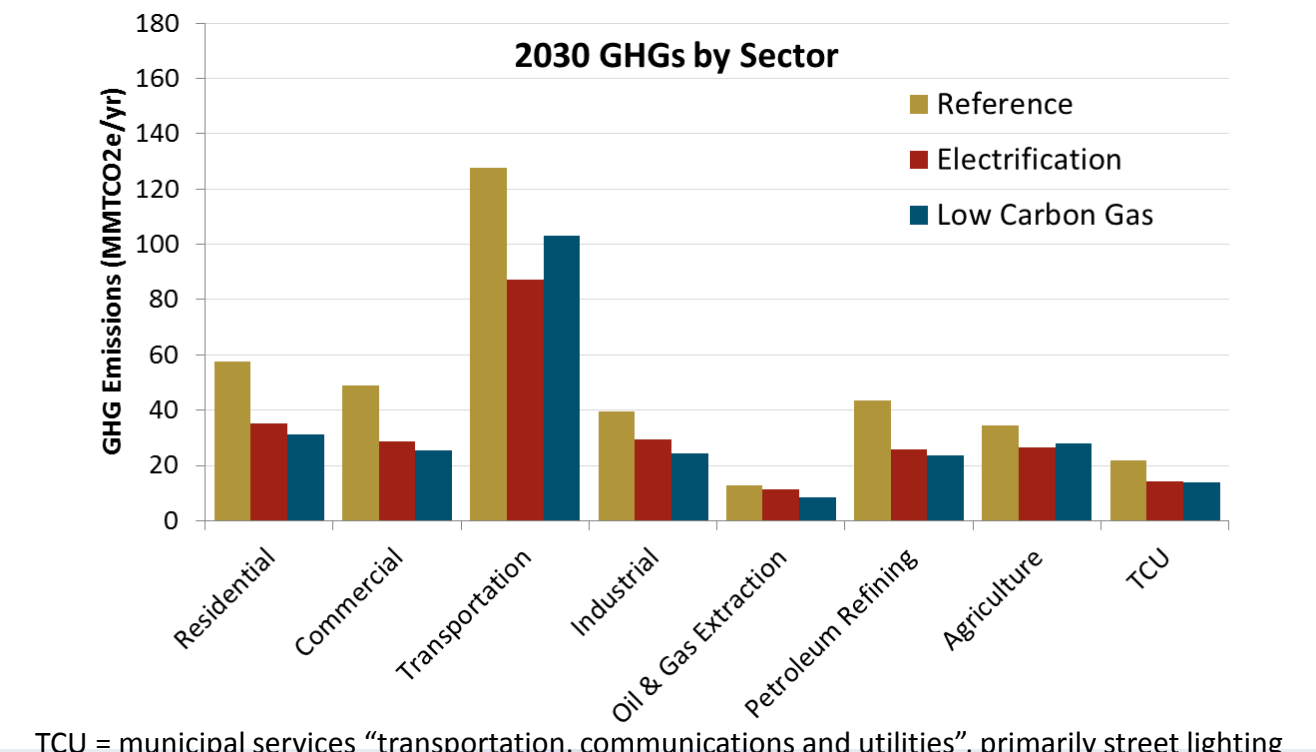
Low Carbon Gas Scenario Avoids Extensive Building Retrofits

» The Low Carbon Gas Scenario: does not assume retrofits to all-electric homes, relies on high efficiency gas appliances and electric efficiency



GHG Reductions in Buildings are Larger in Low Carbon Gas Scenario

- The Low Carbon Gas Scenario achieves lower GHG emissions in the residential, commercial, and industrial sectors
- The Electrification Scenario achieves lower GHG emissions in the transportation sector
- Total GHG emissions are the same in both scenarios

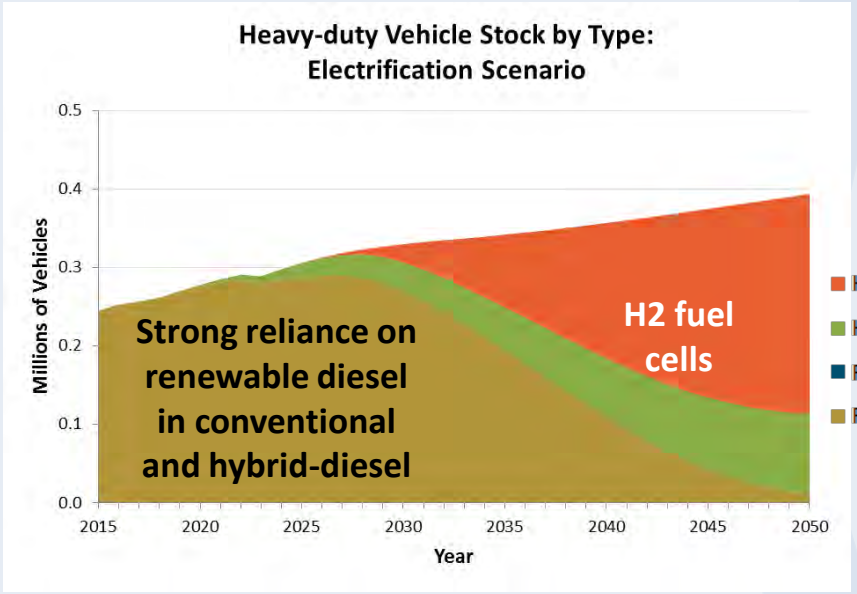


TCU = municipal services "transportation, communications and utilities", primarily street lighting

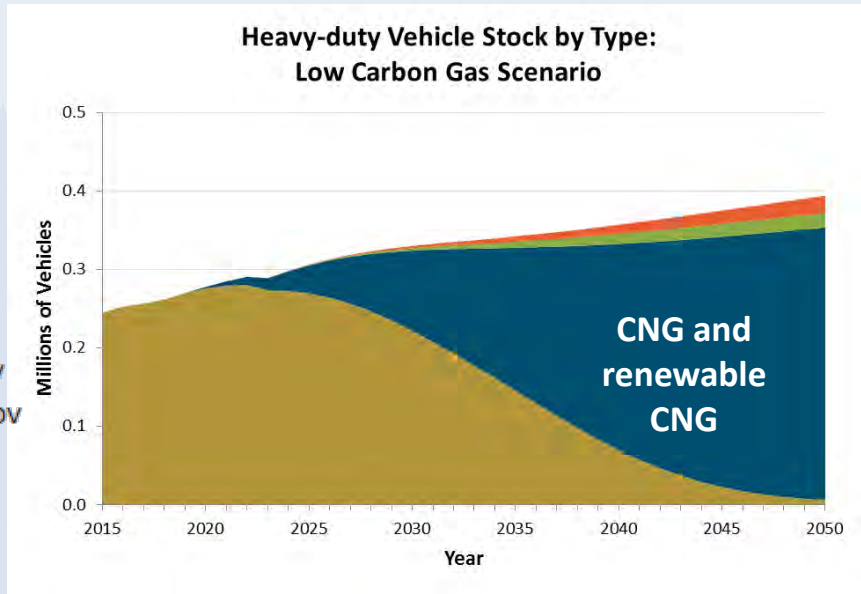
Heavy-duty Vehicle Strategy Varies by Scenario

- The Electrification Scenario: relies on renewable diesel in 2030 plus hydrogen fuel cell and hybrid-diesel heavy duty trucks
- The Low Carbon Gas Scenario: relies on renewable CNG heavy duty vehicles, less reliance on fuel cell and hybrid-diesel trucks

Strong reliance on renewable diesel, & by 2035, renewable gasoline

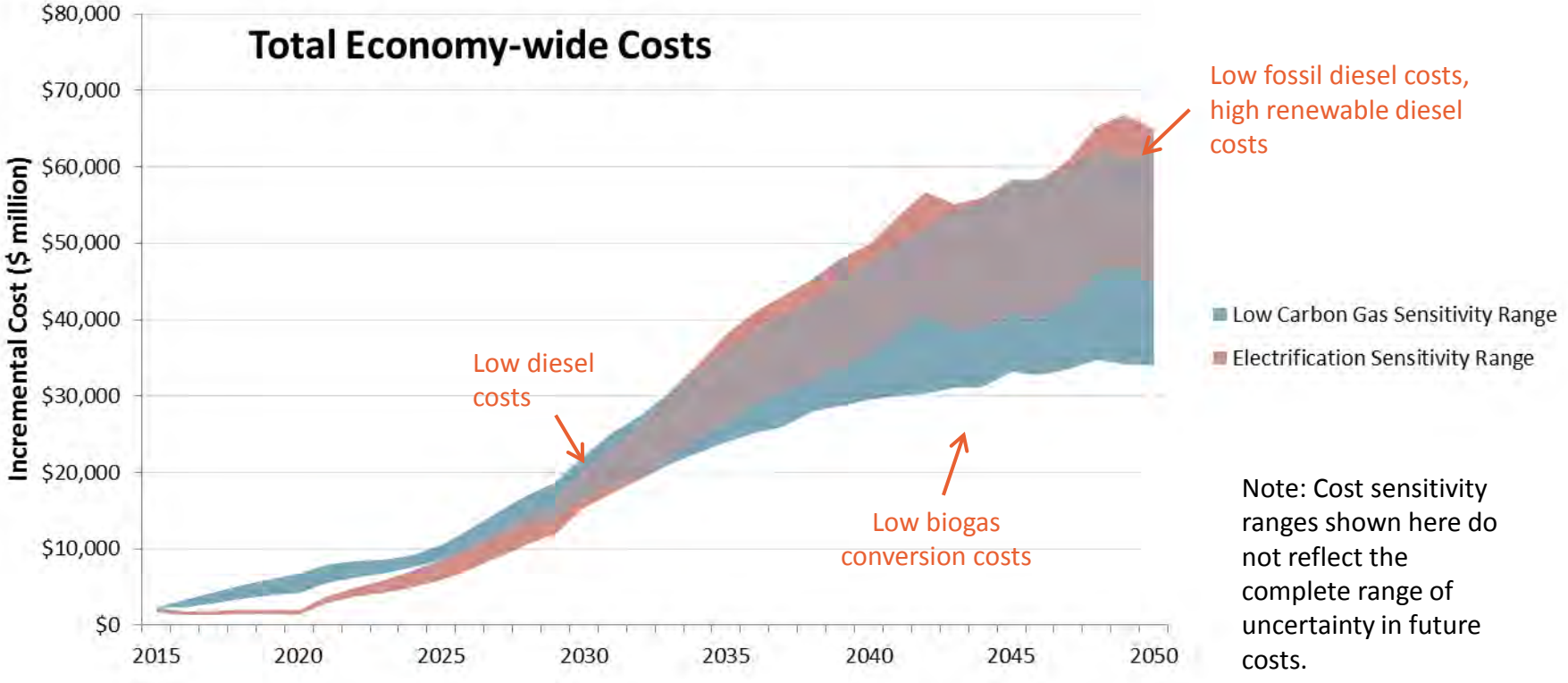


Renewable gas CNG



Economy-wide Costs of Scenarios are Similar, within Uncertainty Range

- Scenarios range from $15 - $22 billion annual cost relative to Reference scenario in 2030
- Cost range shown is driven by uncertainty in costs of biogas vs. fossil natural gas and renewable diesel vs. fossil diesel



Note: Cost sensitivity ranges shown here do not reflect the complete range of uncertainty in future costs.

Summary of Key Risks by Scenario in 2030

- **Low carbon gas scenario may be less risky than electrification**

Electrification scenario	Technology risk	Cost risk	Practical feasibility risk
All electric buildings	Heat pumps	Moderate	Retrofit existing buildings
Fuel cell trucks	Pre-commercial	High	H_2 production & re-fueling
Diesel & hybrid diesel trucks	Available	Moderate	May not meet NOx air quality goals
Renewable diesel	Fisher-tropsch, pyrolysis, hydrolysis	Not commercialized	Drop-in fuel

Low Carbon Gas scenario	Technology risk	Cost risk	Practical feasibility risk
Biogas for buildings	Gasification	Not commercialized	Drop-in fuel
CNG trucks	Available	Moderate	Re-fueling infrastructure
Biogas	Anaerobic digestion	Low	Drop-in fuel, but limited supply
	Gasification	Not commercialized	Drop-in fuel

Background Slides
(Power to Gas)

Power-to-Gas Definition

Wikipedia

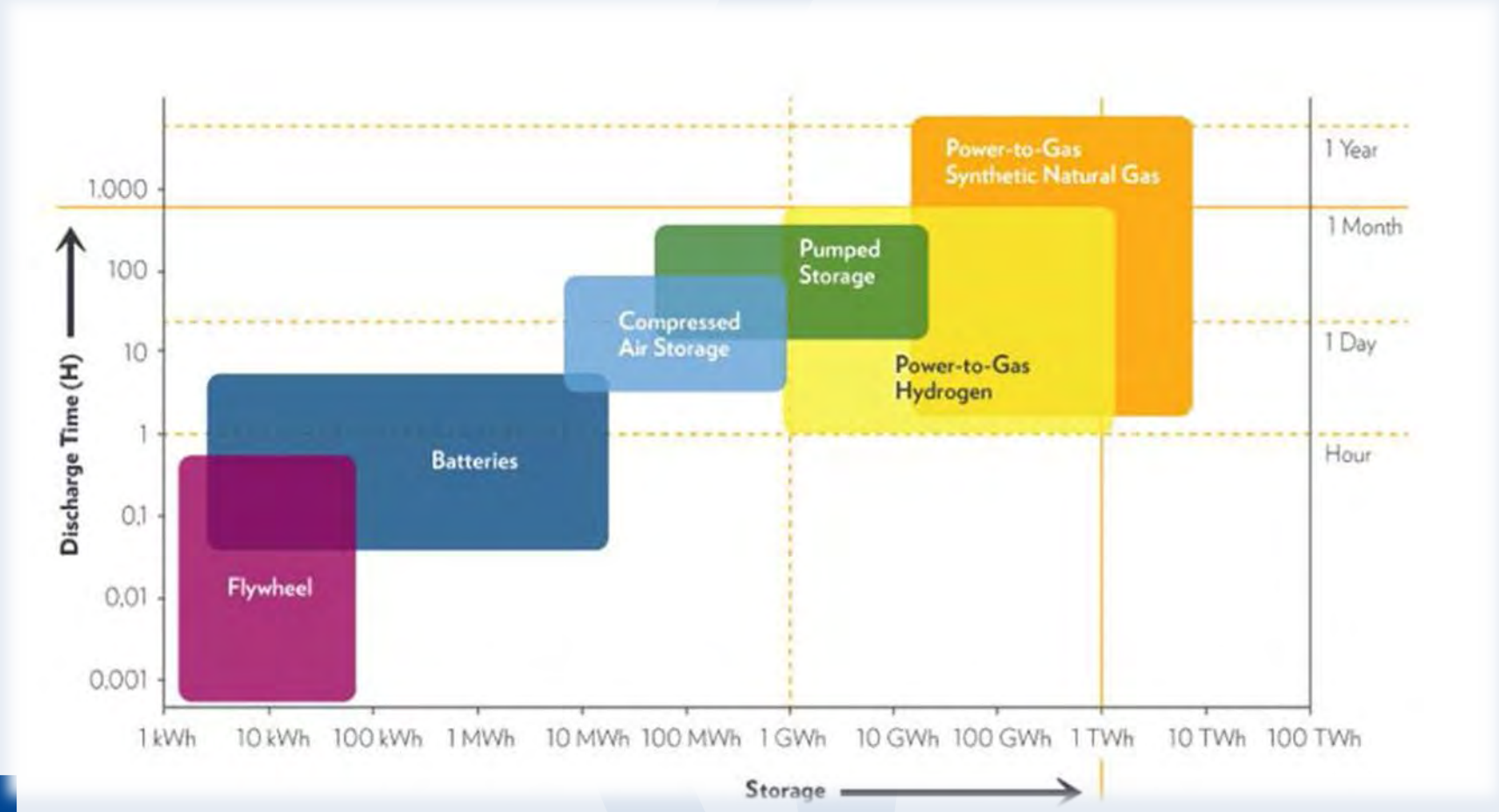
Power-to-gas (often abbreviated P2G) is a technology that converts electrical power to a gas fuel
... use electricity to split water into hydrogen and oxygen by means of electrolysis
... the resulting hydrogen is injected into the natural gas grid or is used in transport or industry
... combine the hydrogen with carbon dioxide and convert the two gases to methane (see natural gas) using a methanation reaction such as the Sabatier reaction
... the methane may then be fed into the natural gas grid

Efficiency

Method Electricity → Gas	Efficiency
Hydrogen	57-73%
Methane (SNG)	50-64%

The power-to-gas methane method is to combine hydrogen from an electrolyzer with carbon dioxide and convert the two gases to methane…

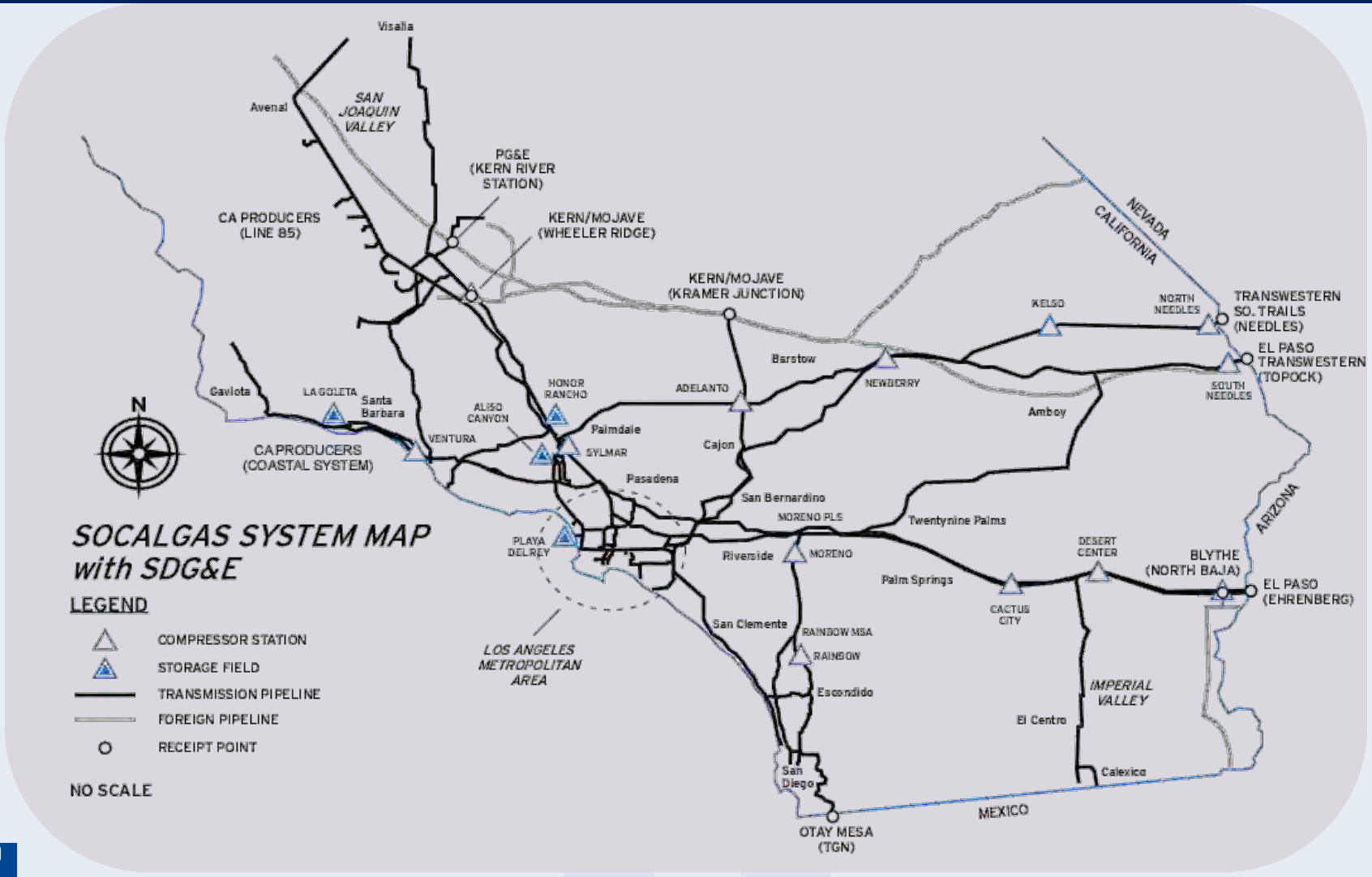
Gaseous Fuels Provide
Unique Storage Functionality



Methane as a Storage Medium

SoCalGas' storage fields are the largest energy storage resource in the region

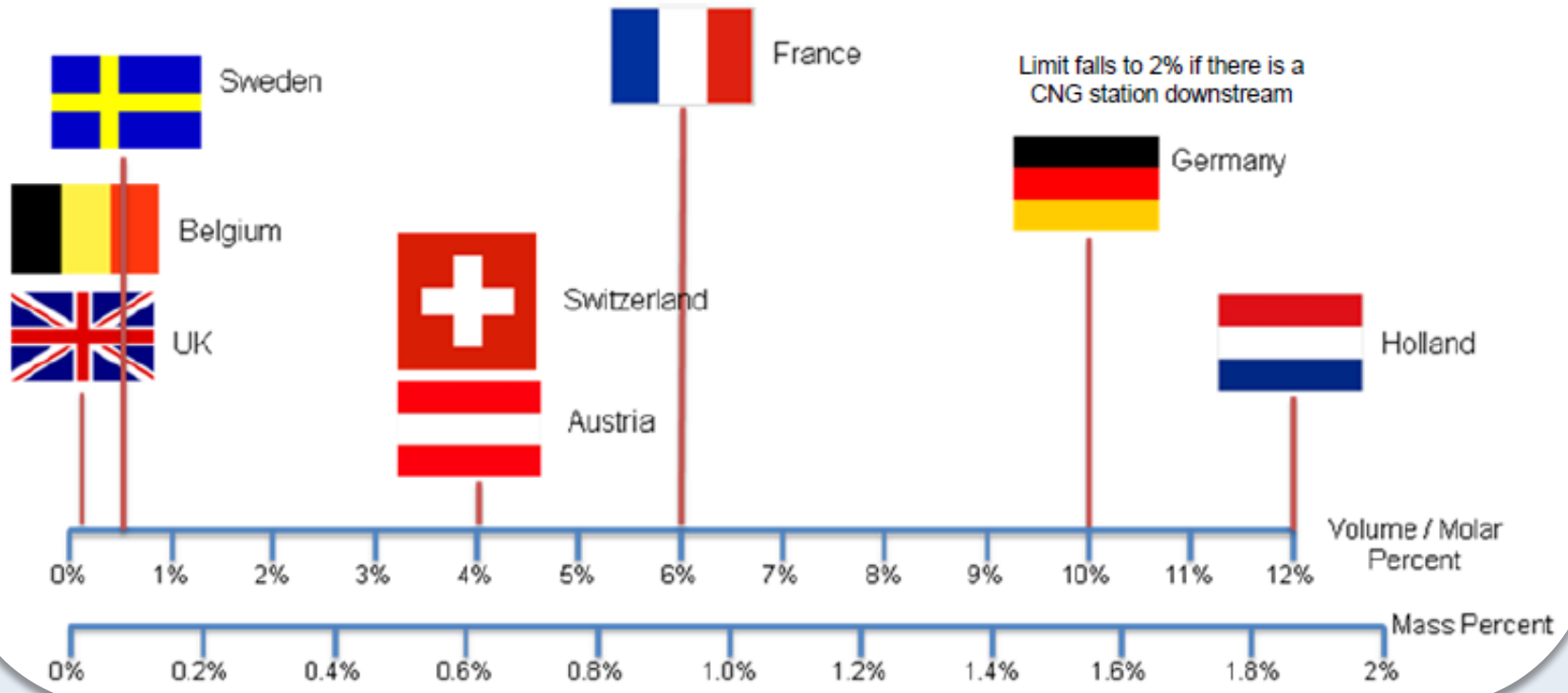
Fully Built Delivery System



Hydrogen Specs

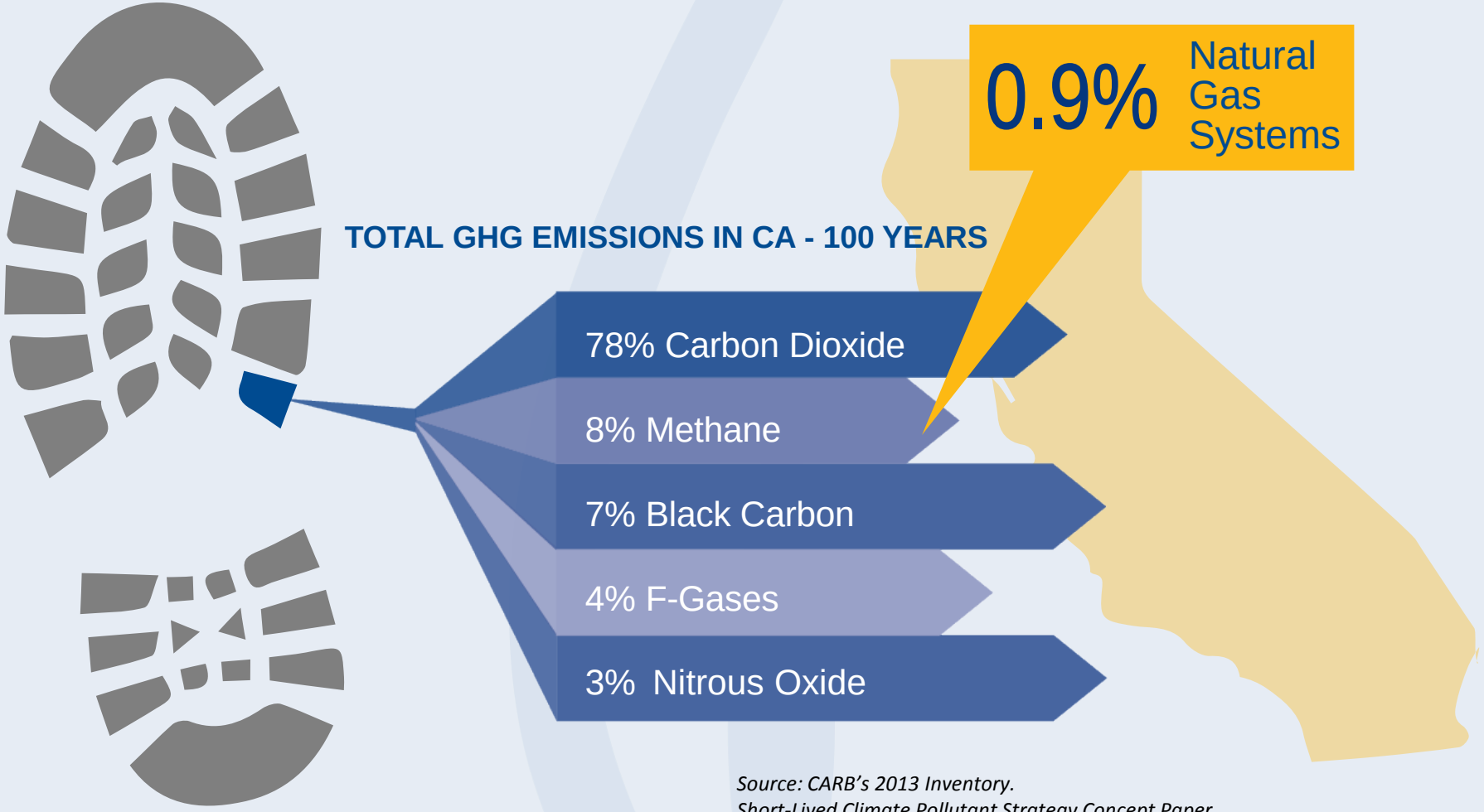
EU Hydrogen Limits for Injection into the HP Gas Grid

Covered by a range of local laws and EU Directives



Background Slides
(Methane Emissions)

METHANE EMISSIONS FROM NATURAL GAS SYSTEMS
Part of California's GHG Emissions

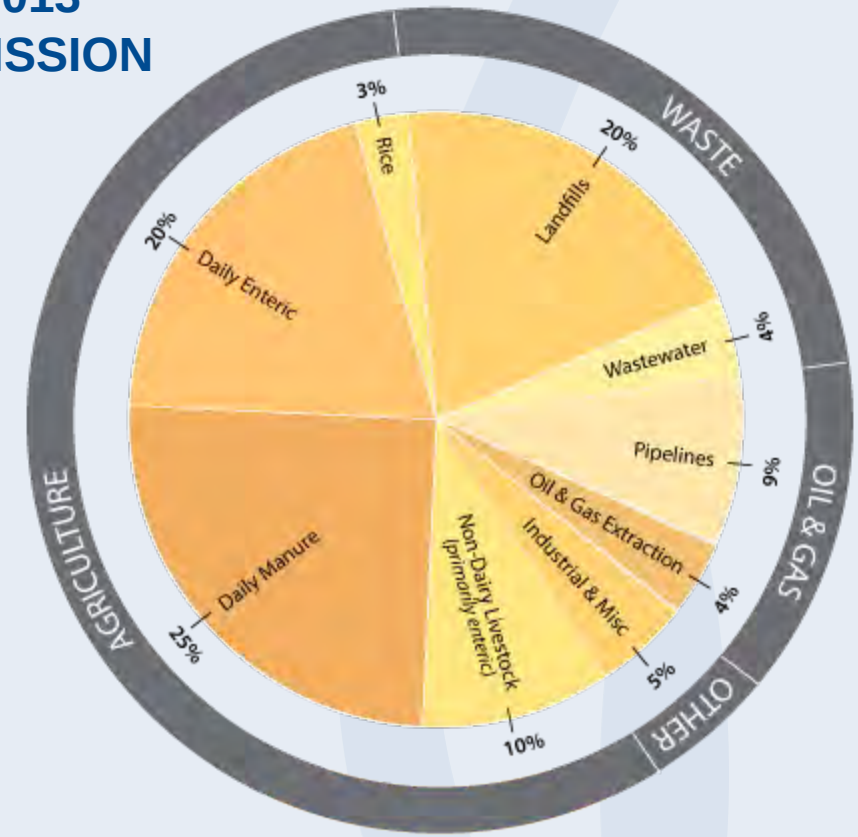


Source: CARB's 2013 Inventory.
Short-Lived Climate Pollutant Strategy Concept Paper.

CALIFORNIA'S METHANE INVENTORY

CALIFORNIA 2013 METHANE EMISSION SOURCES*

2013
118 MMTCO$_2$e

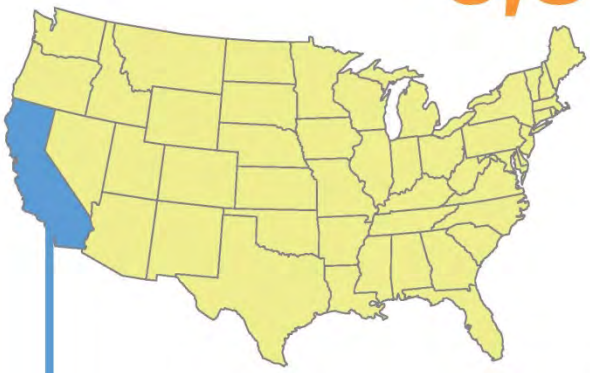


Natural gas systems ~ 9%

Agriculture & waste contribute 82% of the state's methane emissions

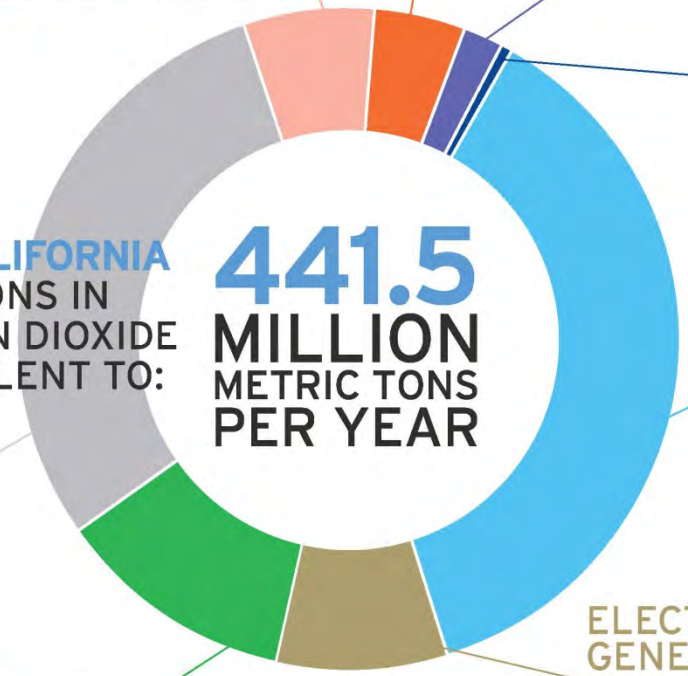
*Using 20-yr GWP

ADDRESSING EMISSIONS
at Aliso Canyon



ALL U.S. EMISSIONS IN CARBON DIOXIDE EQUIVALENT: 6,870 MILLION METRIC TONS

ALL CALIFORNIA EMISSIONS IN CARBON DIOXIDE EQUIVALENT TO: 441.5 MILLION METRIC TONS PER YEAR



DAIRIES
19.6 MILLION METRIC TONS

PETROLEUM REFINING
29.3 MILLION METRIC TONS

LANDFILLS
8.3 MILLION METRIC TONS

ALISO CANYON GAS LEAK
2.1 MILLION METRIC TONS
(From Oct. 23 - Feb. 18)

TRANSPORTATION
163 MILLION METRIC TONS

ELECTRICITY GENERATION (IMPORTS)
36.5 MILLION METRIC TONS

ELECTRICITY GENERATION (IN STATE)
51.8 MILLION METRIC TONS

ALL OTHER
130.9 MILLION METRIC TONS

SoCalGas
A Sempra Energy utility®

STUDIES SHOW EMISSION DECLINE

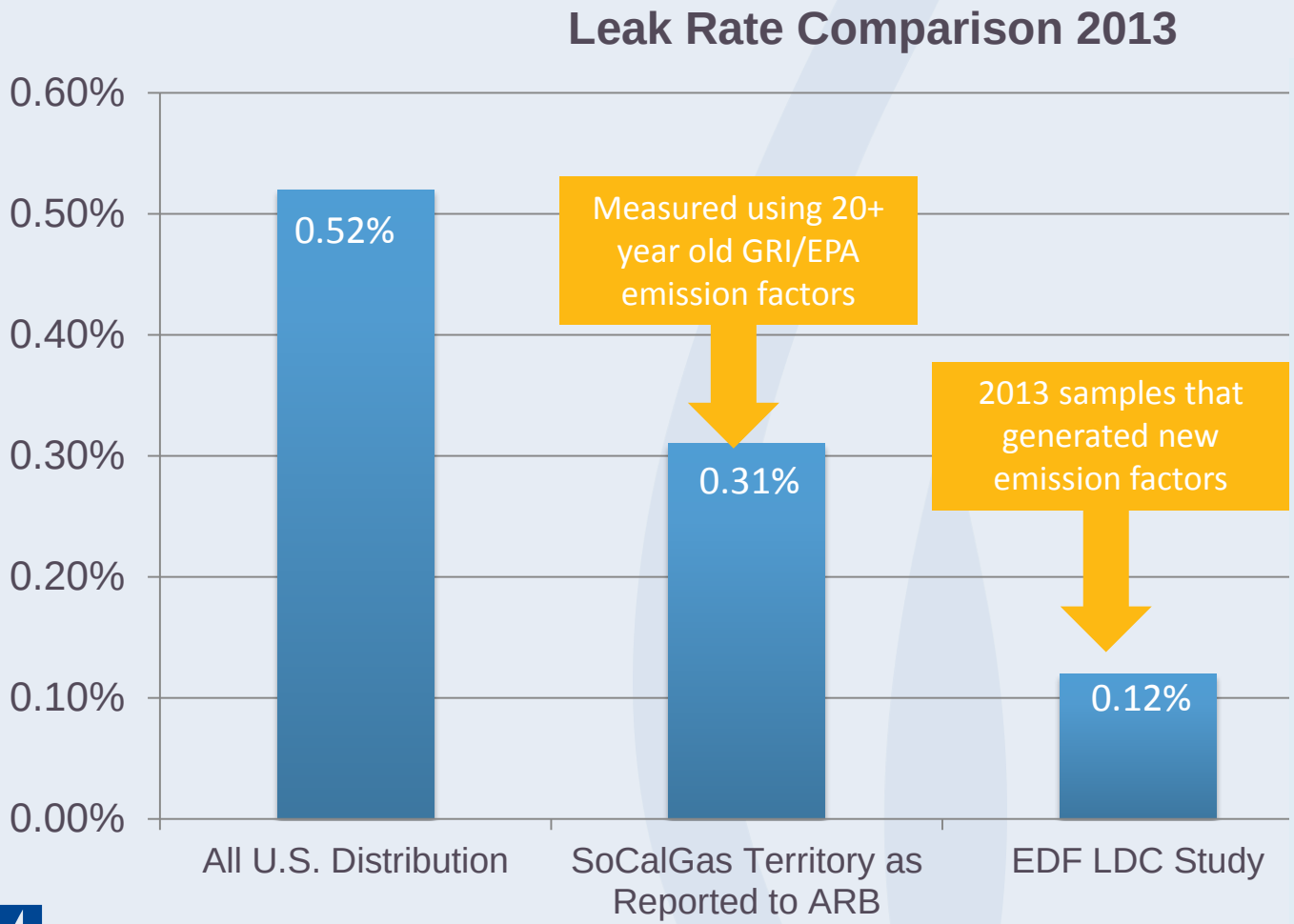
Environmental Defense Fund Study of Natural Gas Systems

SoCalGas is Participating

PRODUCTION	GATHERING & PROCESSING	LONG DISTANCE TRANSMISSION & STORAGE	LOCAL DISTRIBUTION	PUMP TO WHEELS
				
First study on production shows emissions are “in line” with EPA estimates, but some differences in activity areas	EDF identifying industry partners	Measuring emissions from interstate pipeline systems	Peer review draft: “upper bound on local distribution emissions are 30% less than current EPA estimates”	Measuring emissions from medium and heavy duty truck and CNG/LNG fueling stations

STUDIES SHOW LOWER LEAK RATES
for SoCalGas

primarily due to system modernization and better leak detection



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