


SoCalGas RD&D Clean Transportation

**Natural Gas Vehicle Forum
February 21, 2018**

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California Climate Strategy







An Integrated Plan for Addressing Climate Change



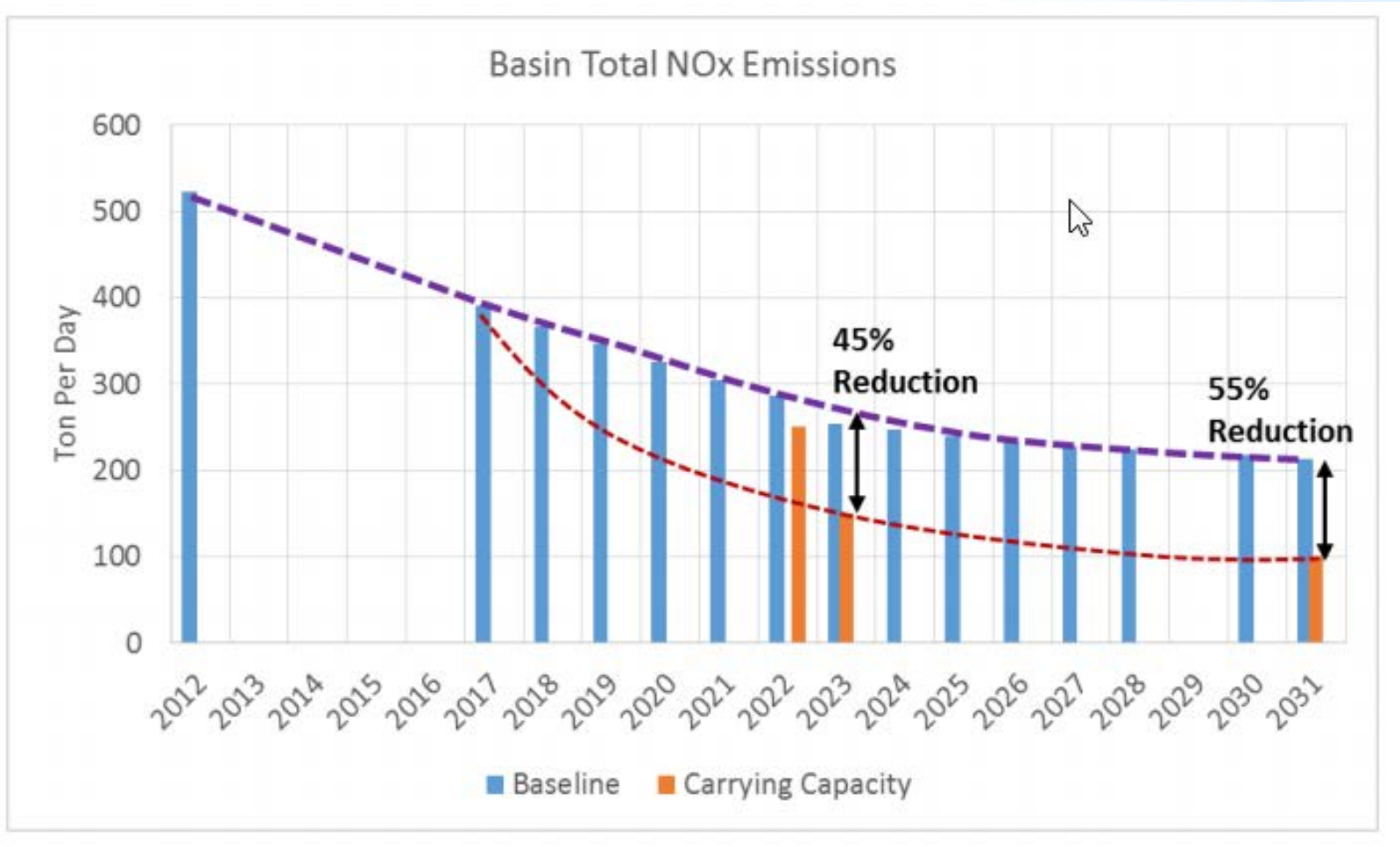
VISION

Reducing Greenhouse Gas Emissions to 40% Below 1990 Levels by 2030

GOALS

- 50% reduction in petroleum use in vehicles**

- Carbon sequestration in the land base**

- Safeguard California**

- 50% renewable electricity**

- Double energy efficiency savings at existing buildings**

- Reduce short-lived climate pollutants**


SCAQMD NOx Emissions Reduction Projection



Customer End-Use Applications



ZNE HOME



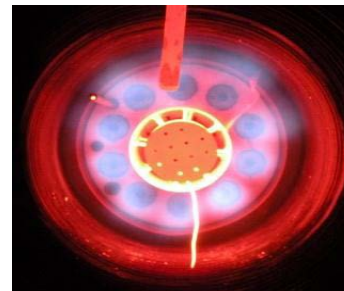
GAS HEAT PUMP WATER HEATER



COMMERCIAL RANGE



LOW NOX RIBBON BURNER



LOW NOX BOILER BURNER



SOLAR THERMAL HEATING & COOLING

Clean Generation



1.5 KW FUEL CELL MCHP



**ORGANIC RANKINE CYCLE
WASTE HEAT TO POWER**



24 KW ICE MCHP

Clean Transportation Overview

☐ Engine

- Near Zero NOx Emissions & Reduce GHG Emissions

☐ Vehicles

- Accelerate the commercial availability of natural gas vehicles
- Improve energy efficiency of natural gas vehicles
- CNG Hybridization

☐ Compression & Refueling

☐ Fuel System & Storage

- Improve CNG tank storage and refueling efforts

☐ Renewable Gas

- Advance the clean and cost-effective production of renewable natural gas for transportation use



Natural Gas Engine Development

Engine Development: Develop and obtain near-zero NOx levels while continuing to meet or exceed other emission standards without incurring a fuel economy penalty

Engine Projects

- Cummins Westport ISL 8.9L NZE – **Commercial**
- Cummins Westport ISX 12L NZE - **Commercial**
- PSI & Ricardo NZE 8.8L Near Zero Emission Engine
- Westport Innovations Advanced Ignition
- EnerPulse Plasma Ignition System
- CNG Engine Efficiency Improvement - SwRI

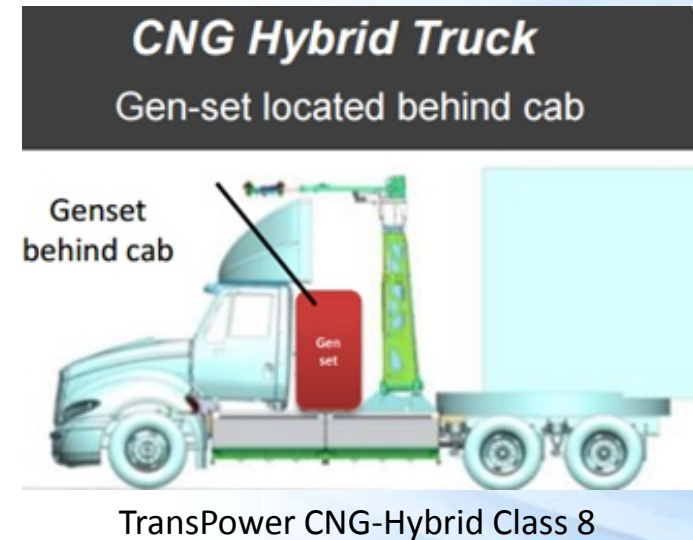


Natural Gas Vehicle Development

Vehicle Development: Develop and demonstrate near zero emission engines and vehicle designs reduce emissions promote advanced vehicle technology

Current Vehicle Projects

- Zero Emission Cargo Transportation I & II
 - *TransPower, US Hybrid*
 - *Kenworth/BAE*
- CNG Plug-In Hybrid Drayage Truck
 - *US Hybrid*
- Commercial Zero Emission Vehicle Roadmap
 - *NREL, Ricardo*
- In-Use Emission Study
 - *WVU, UCR, SCAQMD, CEC*



Compression & Refueling

Development: Develop technologies and processes to reduce emissions, improve equipment efficiency, and improve economics

Compression Projects:

- OnBoard Dynamics Mobile Compressor
- Free Piston Linear Motor Compressor

Refueling Projects:

- Advanced Full Fill Demonstration



Galileo Micro Compressor



OnBoard Dynamics Mobile Compressor

Fuel System & Storage

Development: Develop and demonstrate advanced natural gas tank technologies providing a safe, low-pressure, high-density, conformable storage system that enables cost-effective refueling

Fuel System & Storage Projects:

- ANGP Low Pressure and Advanced Conformable Fuel Storage Tank



Off-Road Applications

Development: Develop technologies off-road applications towards Near Zero Emissions and improve efficiency

- VeRail Low NOx Switch Locomotive

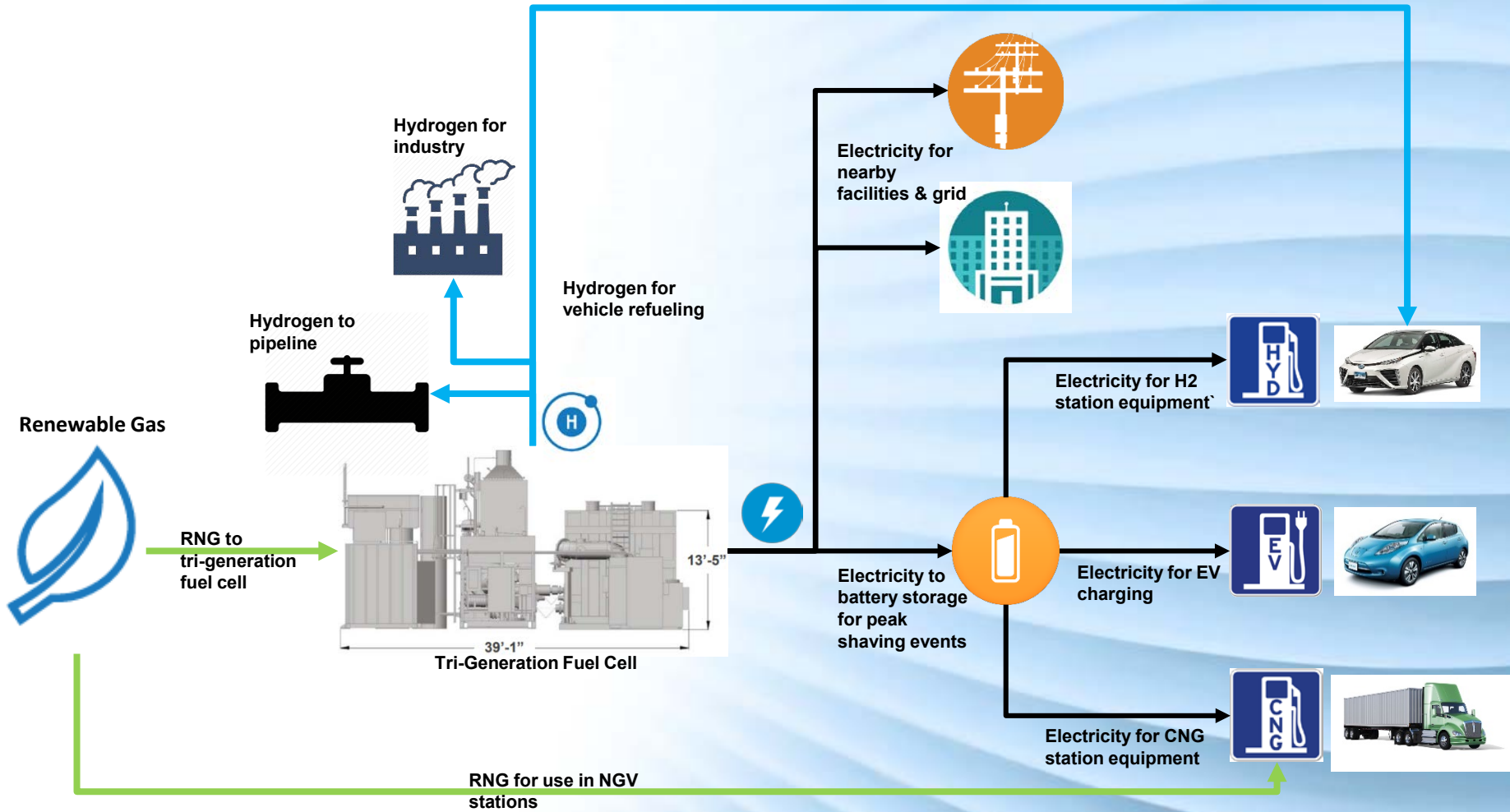


Moving Forward...

Natural gas vehicle technologies and their associated performance will need to experience significant levels of innovation in the following key topic areas to keep up with incumbent and emerging technologies and meet future regulations:

- Improve Engine Efficiency and Performance
- Promote Near-Zero Emission CNG Engines
- Improve Range and Storage
- CNG-Hybrid Vehicles
- Hydrogen Fuel Cell Class 8 Trucks
- Tri-Generation Fuel Cell Refueling Station

Tri-Generation Fueling System



NEAR-ZERO vs ZERO Emissions HD Trucks & Buses

All Electric Trucks & Buses

CNG-RNG



TESLA



Mercedes-Benz



PROTERRA



NEW FLYER



BLUE BIRD

Fuel Cell



TOYOTA



Solar-Thermal Heating & Cooling Demo

