

# Ultra Low Emission Control for Rich Burn Engines

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California Energy Commission  
IEPR Lead Commissioner Workshop  
Combined Heat and Power to Support  
California's Climate Change Scoping Plan

## ***Technology Innovation to Overcome CHP Barriers***

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# Quest To Lower Engine Emissions

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- Engine CHP is least cost technology option < 5 MW
- Regulations continually challenge engine emissions
  - ▣ CARB 2007 Guidelines to the Local Air Districts
  - ▣ South Coast Air Quality Management District (SCAQMD) Rule 1110.2
    - New DG engines to meet the CARB guidelines for NOx
    - Frequent hand-held analyzer checks to ensure continuous compliance
  - ▣ State-wide requirement that DG meet the CARB Guideline for NOx to be eligible for the SGIP and for sell back of excess electricity.
- Complying with these new and expanding emission rules represent a formidable technology leap for reciprocating engines.
- Tighter regulations spreading to other States



# Advanced Technology Solutions

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- Two parallel Energy Commission R&D initiatives
  - ▣ DE Solutions – SCG - Tecogen
  - ▣ SCG – Continental Controls
- Objectives
  - ▣ Exceed CARB 2007 requirements
  - ▣ Sustain CARB 07 performance without frequent testing and operator tuning



# California Engine Emission Limits

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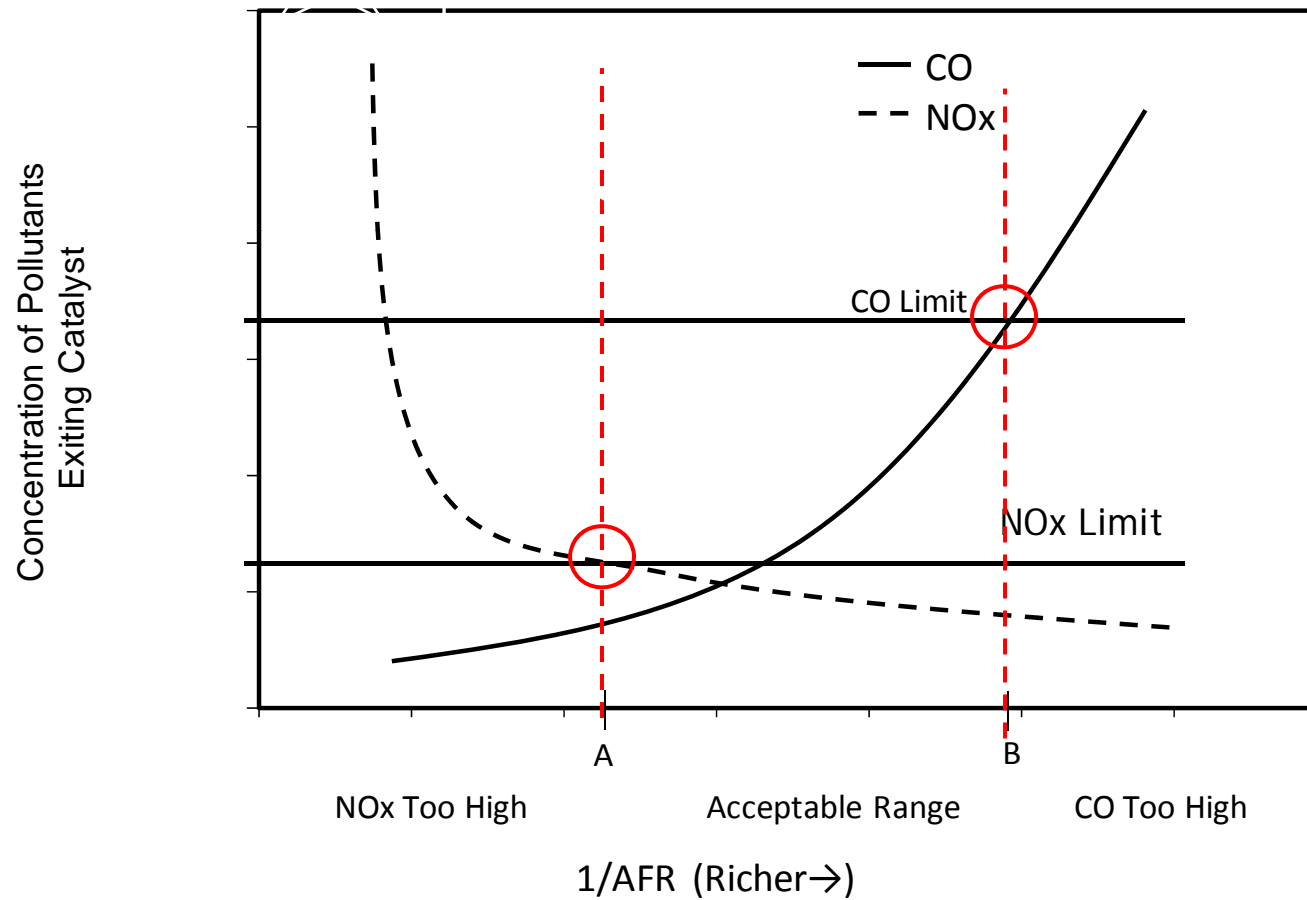
	Lb/MW-hr			ppm @ 15%O2		
	NOx	CO	VOC	NOx	CO	VOC
CARB 07 limit*	0.07	0.1	0.02	3.3	7.9	2.7
SCAQMD DG Limit*	0.07	0.2	0.1	3.3	15.7	13.7
BACT Limit	N/A	N/A	N/A	11	70	N/A

\* With minimum allowable heat recovery credit



# Fundamental Barrier

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# Technology Approaches

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- Tiny compliance window has previously been achieved but not sustained
- Numerous solutions were investigated in both projects
- Two distinctly different solutions emerged
  - Continental Controls Corporation - Precise air/fuel ratio control, pioneering use of emerging NOx sensors for feedback, robust catalyst and dithering
  - Tecogen - Innovative catalyst configuration to widen the compliance window
  - Approaches not mutually exclusive



# Continental Controls Corporation

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- ❑ Electronic Gas Carburetors

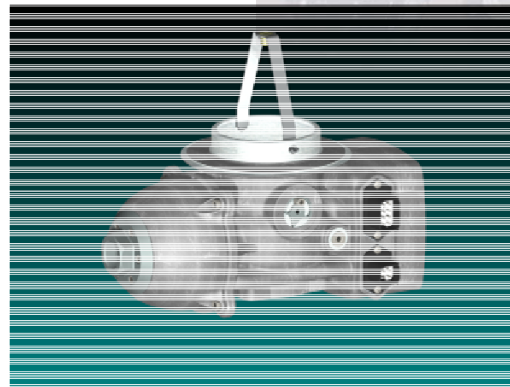
- ▣ The EGC is a unitized electronic pressure regulator, mixing venturi and electronic controls integrated together

- ❑ O2 & NOx sensors

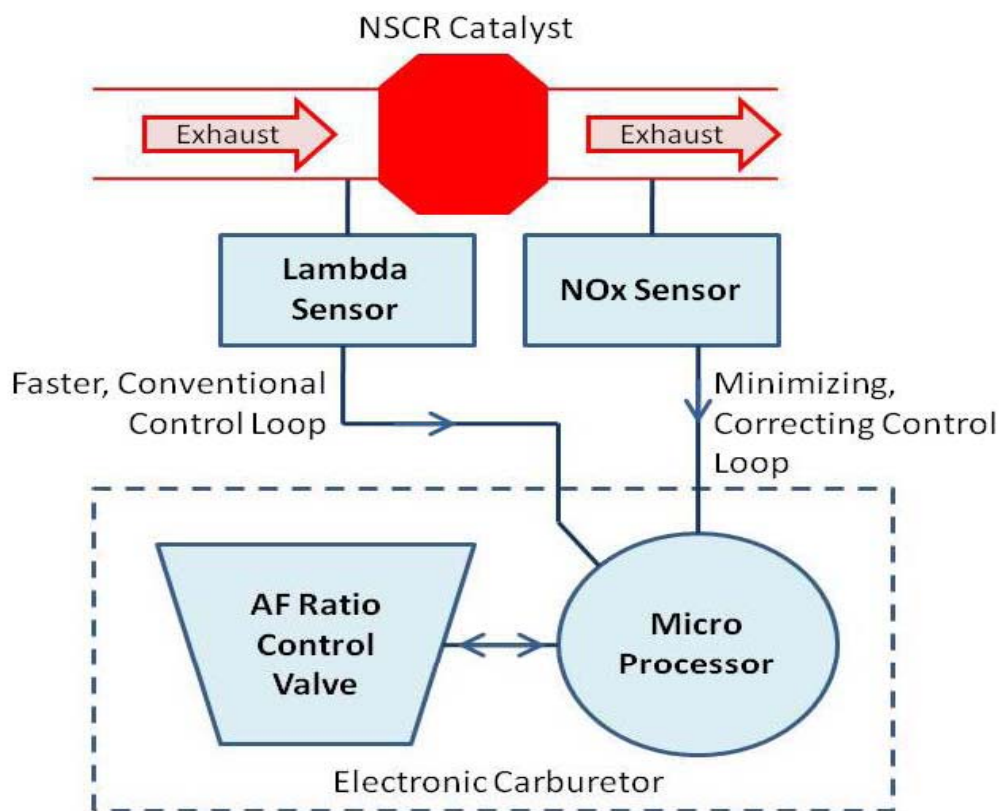
- ❑ Monitor/Controller

- ❑ Robust Catalyst

- ❑ Dithering



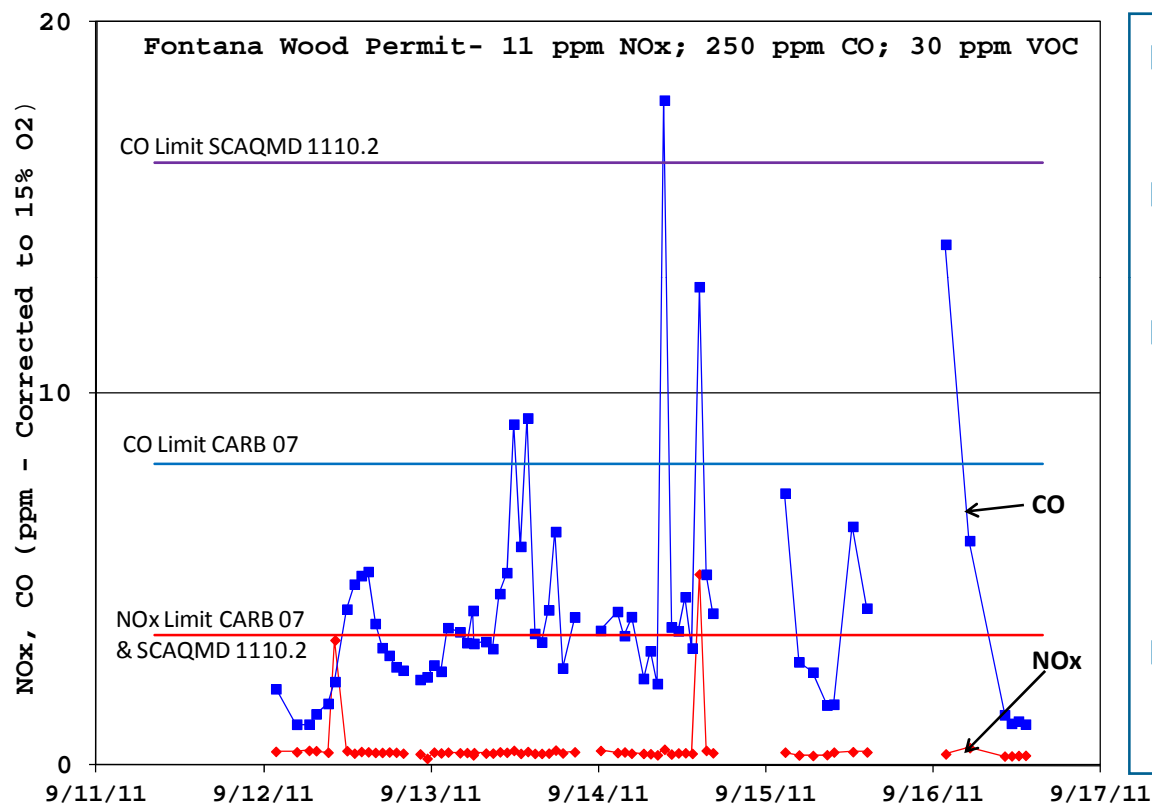
# System Diagram with Dynamic NOx Sensor Feedback





# CCC Representative Field Test Data Fontana Wood

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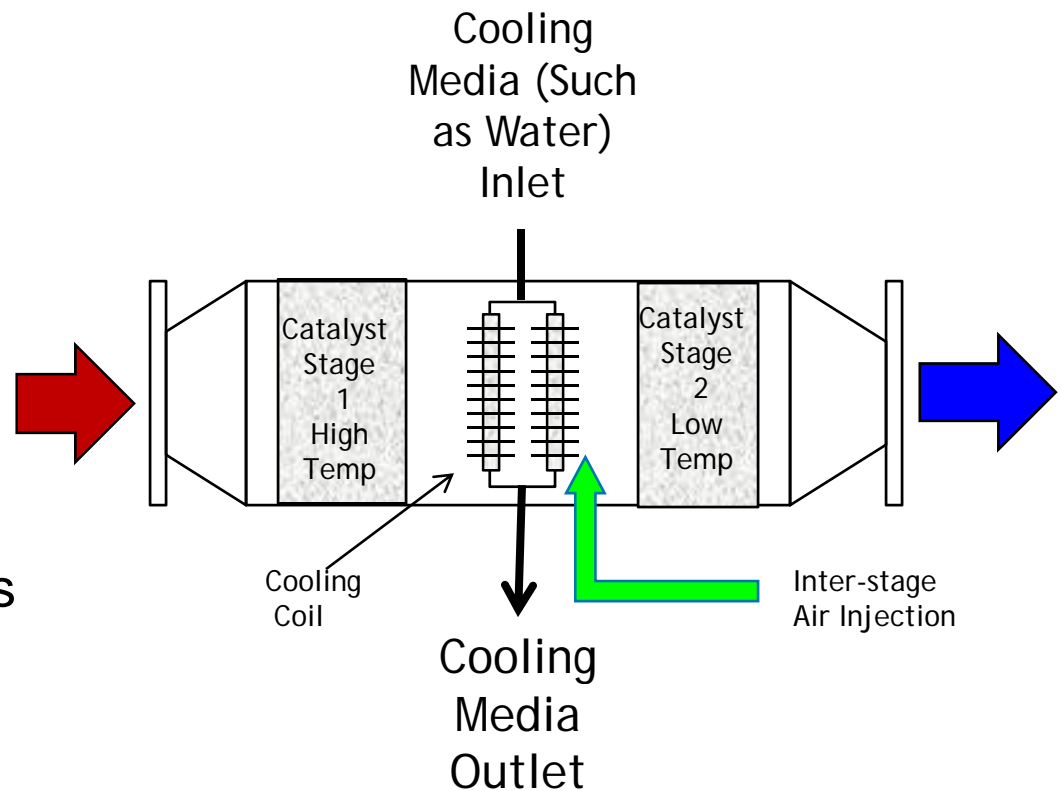


- Atypical CHP application
- Operates at very low loads at times
- Causes infrequent excursions above SCAQMD new DG rule
- Still well below operating permit



# Tecogen – 2 Stage Catalyst

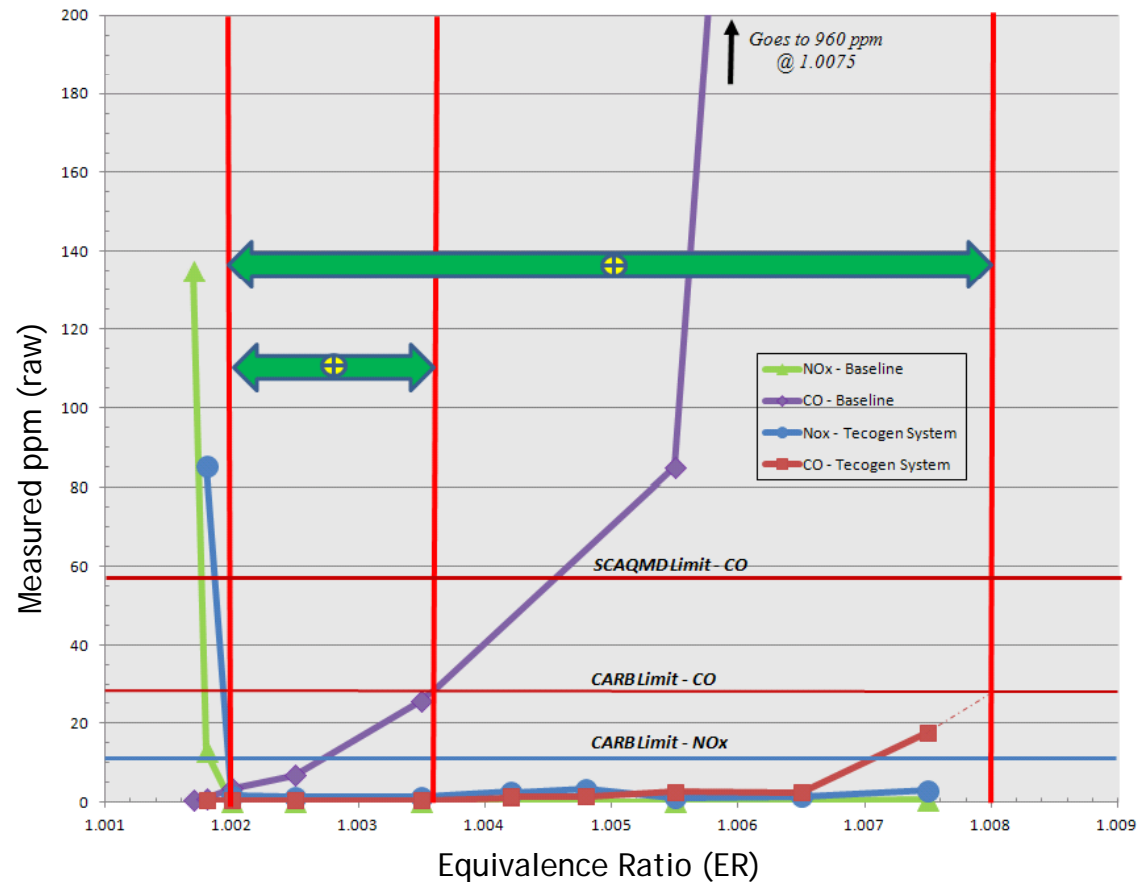
- Decouples NOx and CO treatment
  - 1<sup>st</sup> stage operates rich and reduces NOx to negligible levels
  - 2<sup>nd</sup> stage operates lean to oxidize CO and VOCs to near zero levels
  - Proper conditioning of exhaust prior to 2<sup>nd</sup> stage is critical
- Field Test Program Successful



# AVL Third Party Test

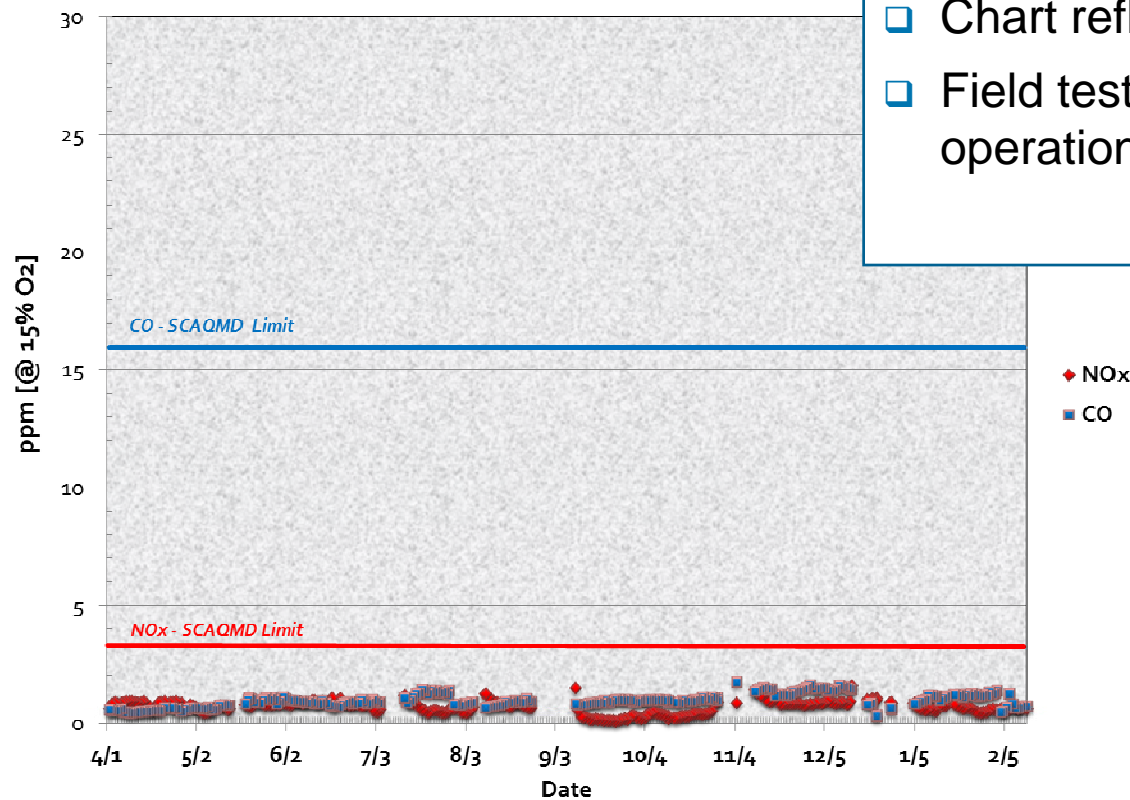
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- ❑ CARB Compliant emissions (NOx and CO near zero)
- ❑ AFR control window widened by nearly four times (375%)



# Tecogen Field Test Data – 10 Months San Fernando Pool

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- Chart reflects 10 months of data
- Field test unit has 12,000 hrs of operation with original catalyst



# Product Commercialization

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## Continental Controls

- ❑ Retrofits currently available for operating engine systems
- ❑ Up-fit kits for Original Equipment Manufacturer (OEM) packagers
- ❑ Future engine OEM offering
- ❑ Patent applied for

## Tecogen

- ❑ InVerde *Ultra* 100 introduced in 2011
- ❑ Integration with other products ongoing - CHP products, engine chillers & heat pump
- ❑ Adaptable to other natural gas engines
- ❑ Patent applied for



# Summary

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- Both emission technology options < 3% cost premium over total CHP system cost.
- Enables least cost technology < 5 MW to remain viable option in California
- Technologies allow continuous compliance with permit limits
- Creates new clean environmental image for engines

