

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

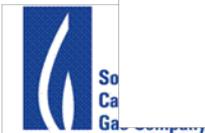
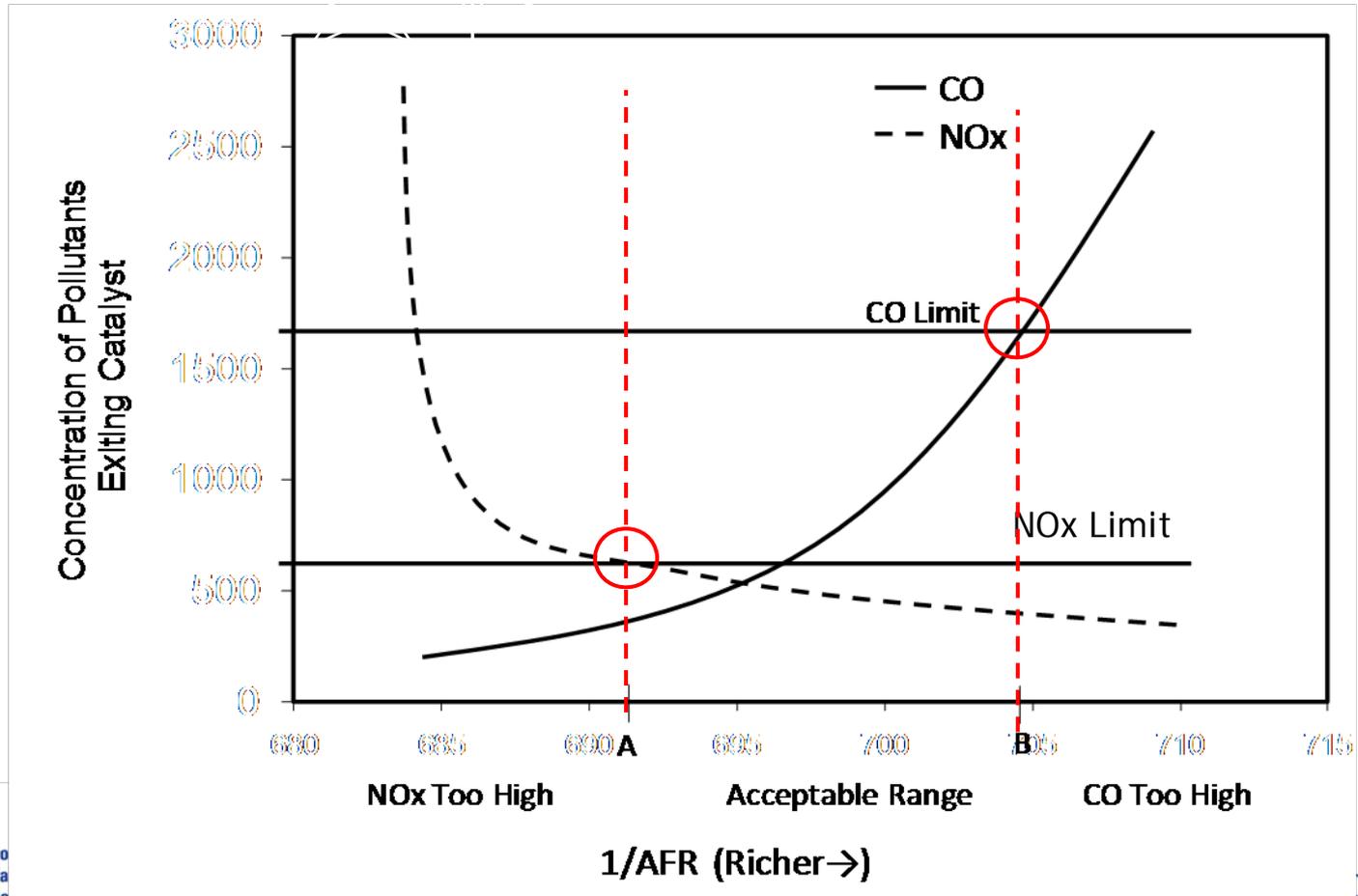
	Lb/MW-hr			ppm @ 15%O2		
	NOx	CO	VOC	NOx	CO	VOC
CARB 07 limit*	0.07	0.1	0.02	3.3	7.9	2.7
SCAQMD DG Limit*	0.07	0.2	0.1	3.3	15.7	13.7
BACT Limit	N/A	N/A	N/A	11	70	N/A

* 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



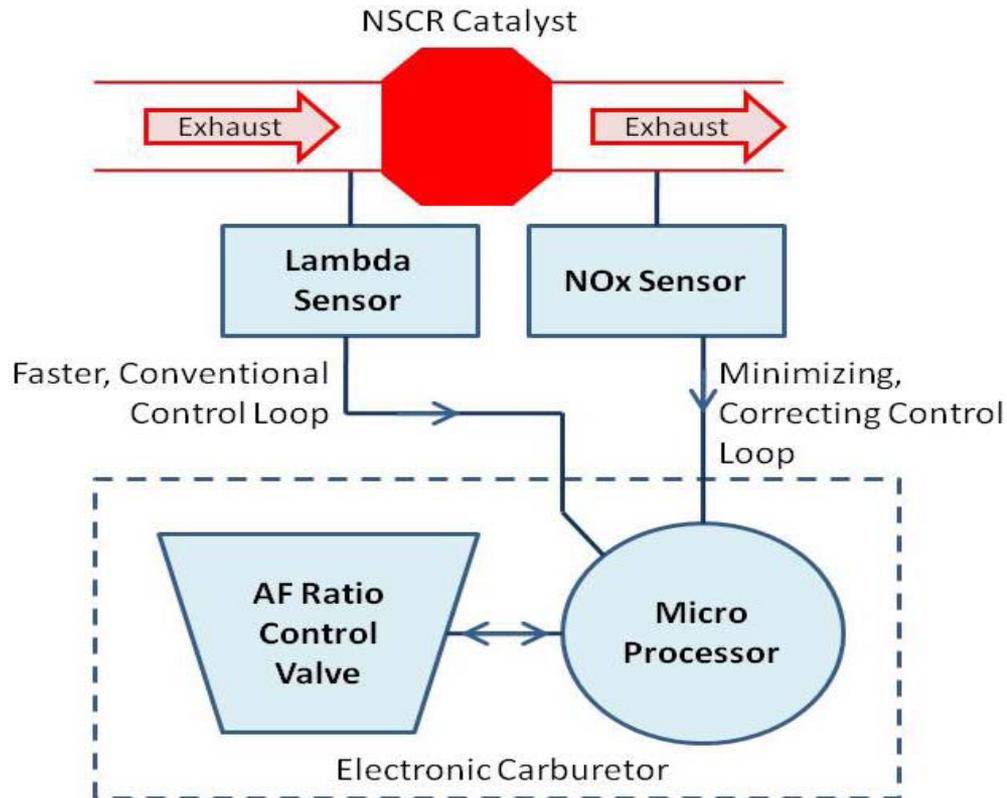
Continental Controls Corporation

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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

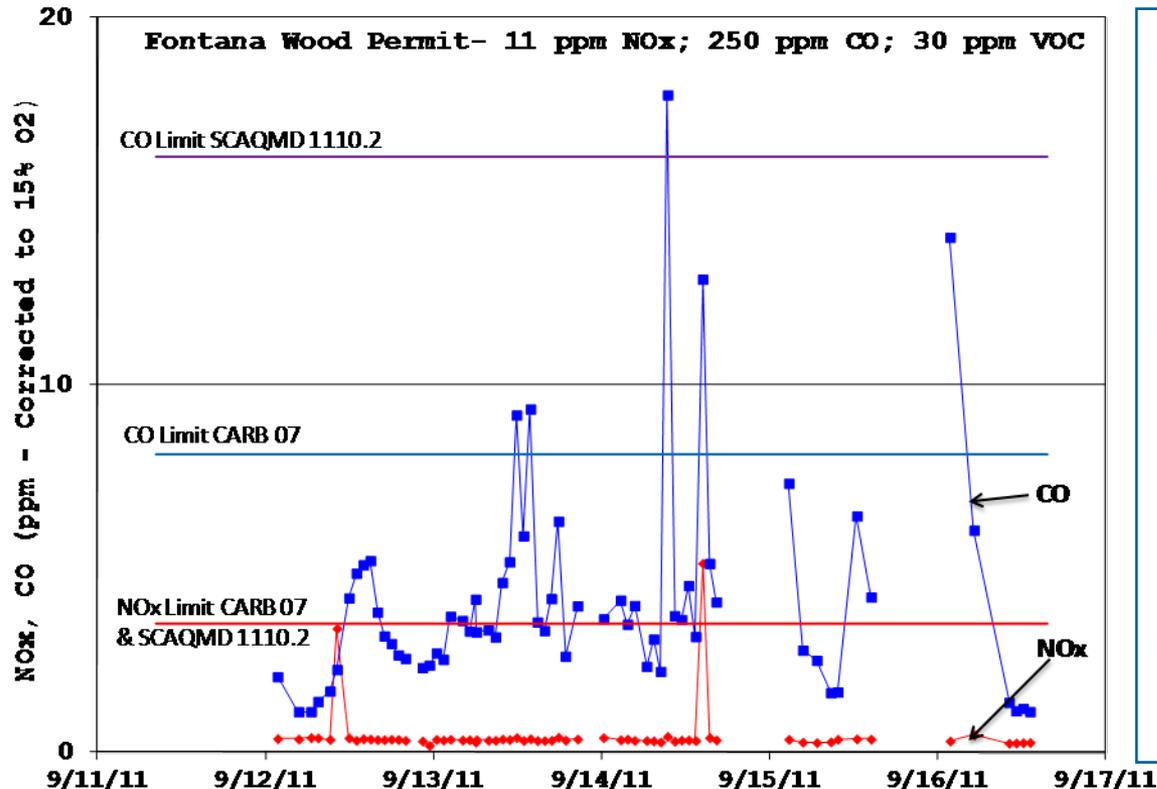


System Diagram with Dynamic NOx Sensor Feedback



CCC Representative Field Test Data Fontana Wood

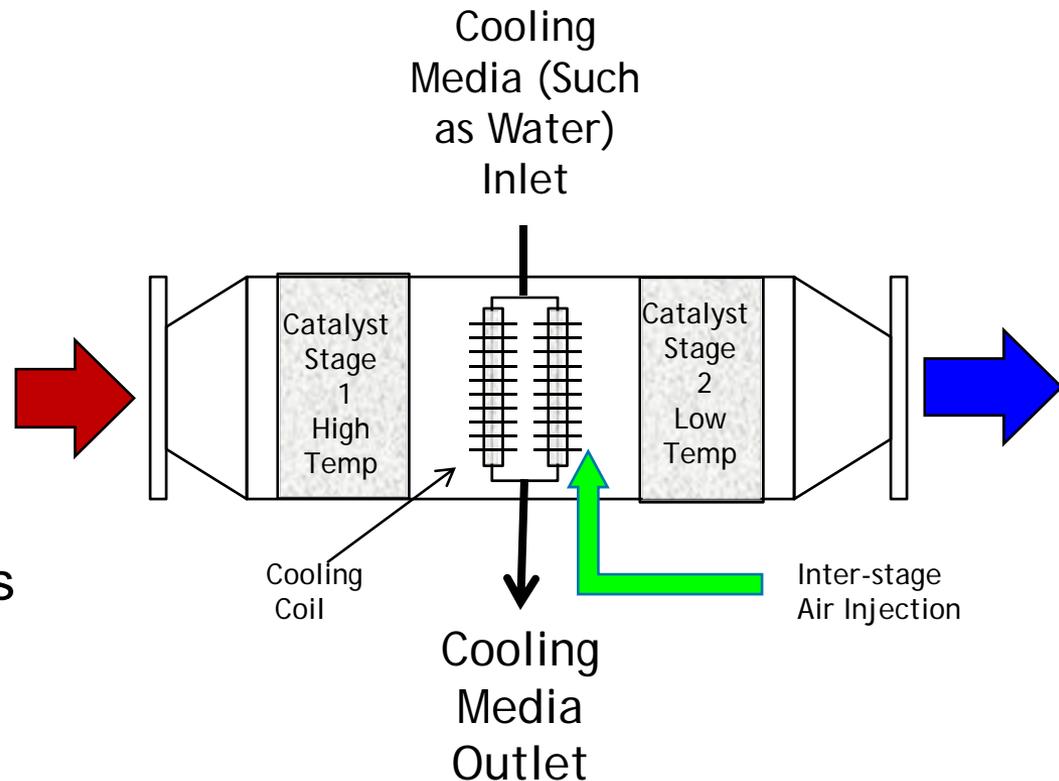
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- Atypical CHP application
- Operates at very low loads at times
- Causes infrequent excursions above SCAQMD new DG rule
- Still well below operating permit

Tecogen – 2 Stage Catalyst

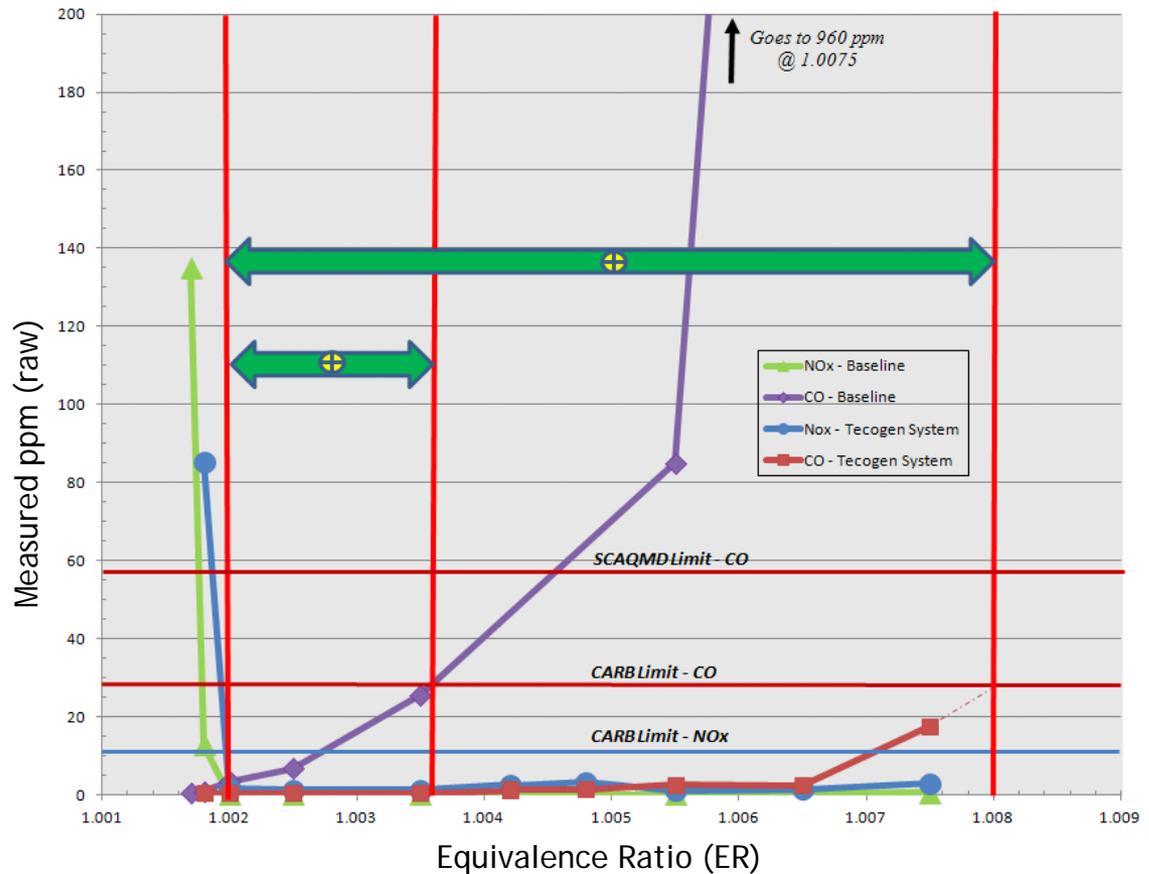
- Decouples NOx and CO treatment
 - 1st stage operates rich and reduces NOx to negligible levels
 - 2nd stage operates lean to oxidize CO and VOCs to near zero levels
 - Proper conditioning of exhaust prior to 2nd stage is critical
- Field Test Program Successful



AVL Third Party Test

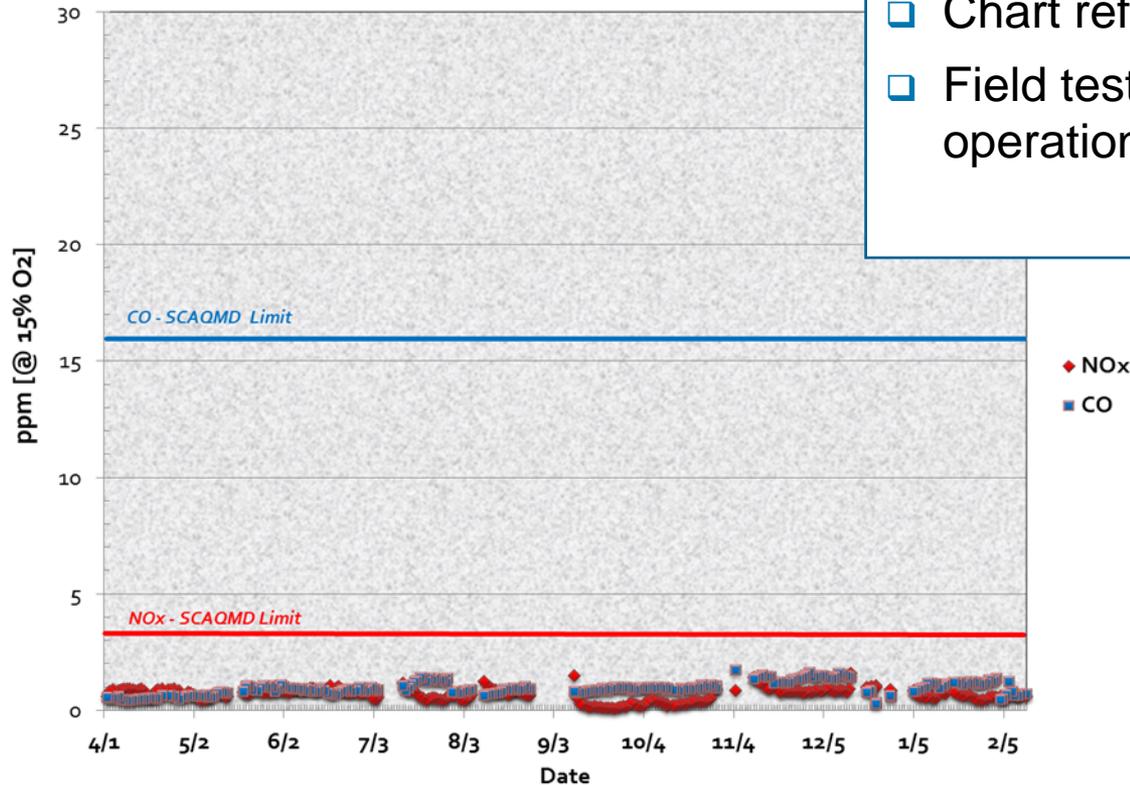
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- ❑ CARB Compliant emissions (NOx and CO near zero)
- ❑ AFR control window widened by nearly four times (375%)



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

