

POWER GENERATION WEEK 2016

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Multi-Pollutant Catalyst for Combustion Turbine Power Plants

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Presentation Overview

- **Multi-Pollutant Catalyst (METEOR™ MPC)**
 - Background
 - Full-Scale Installation



CORMETECH
METEOR™



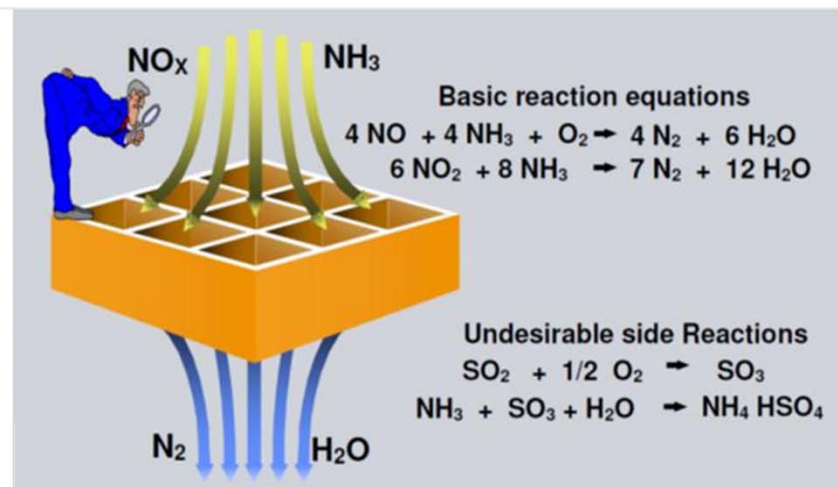
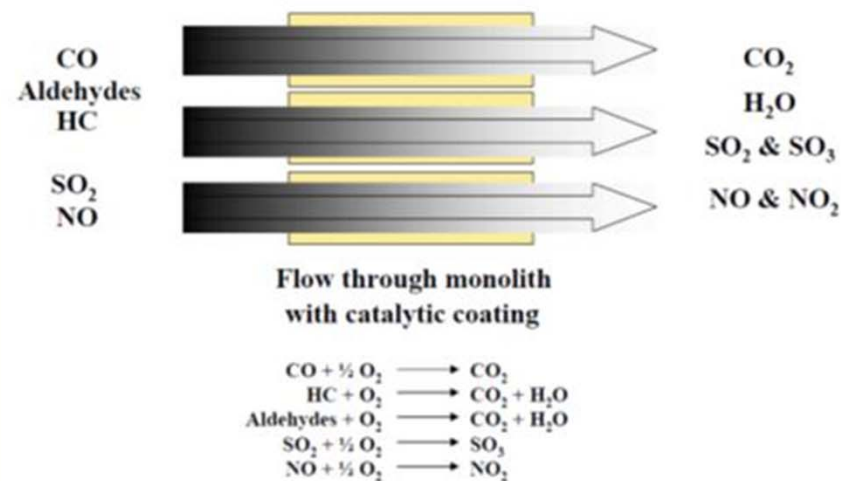
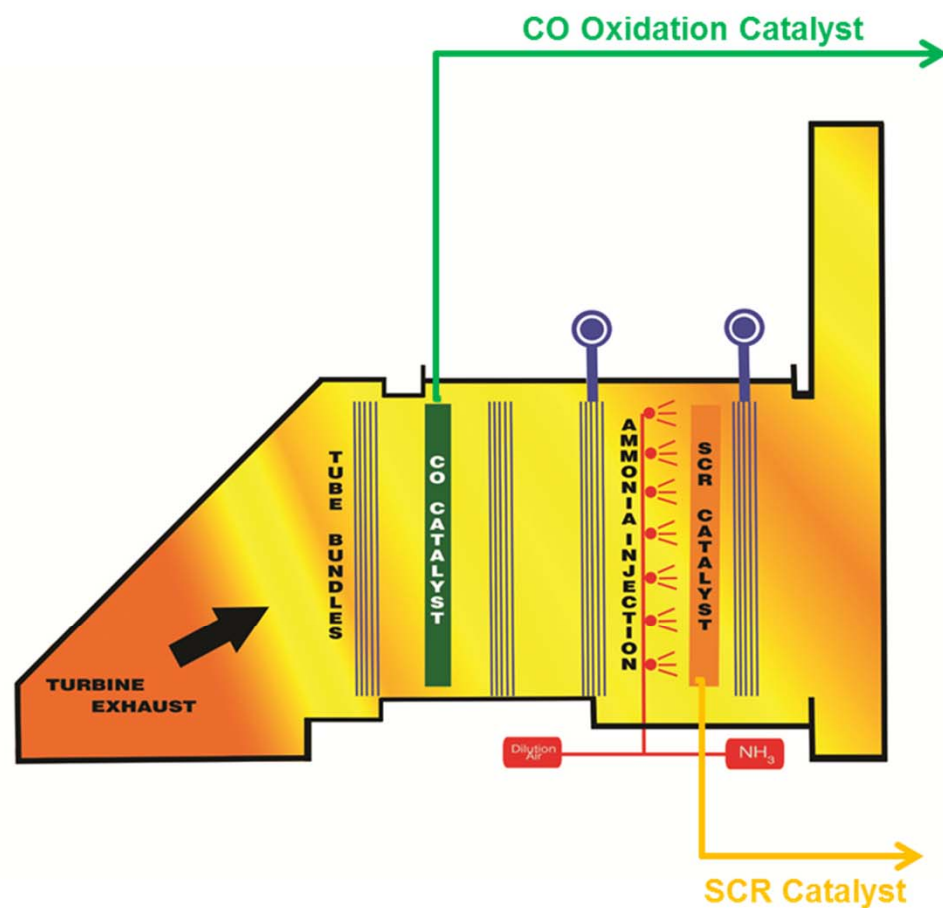
Multi-Pollutant Catalyst (METEOR™ MPC)

→ ***BACKGROUND***

BACKGROUND

Traditional HRSG Layout

→ CO Oxidation Catalyst → AIG → SCR Catalyst



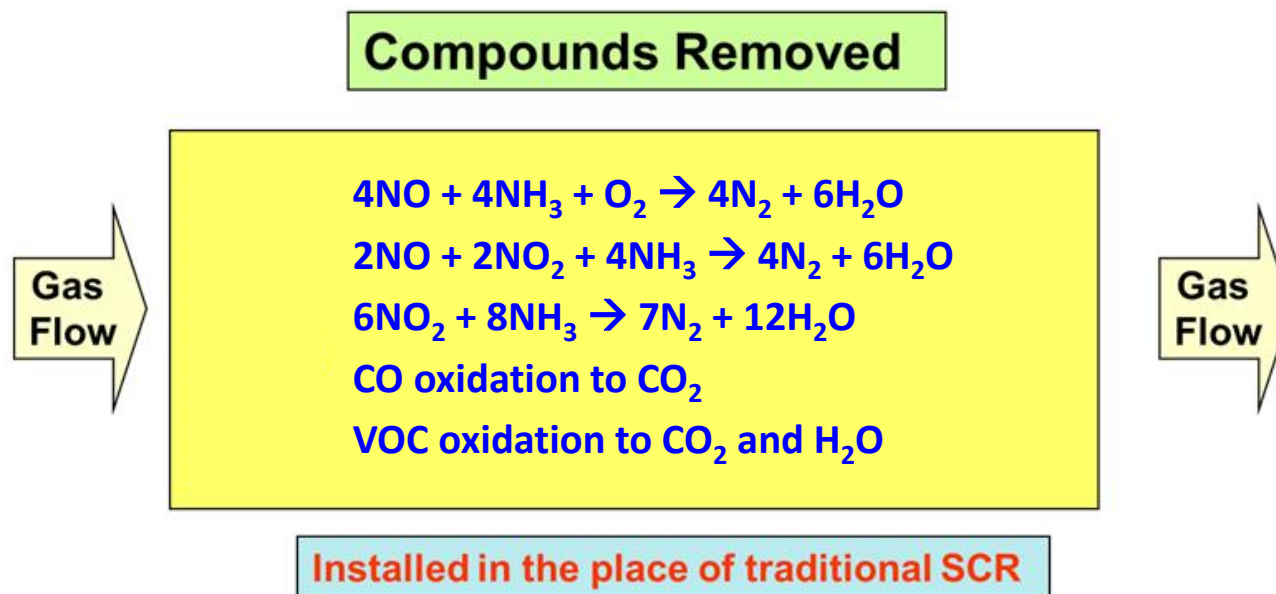
BACKGROUND

Catalyst Overview

METEOR™ MPC



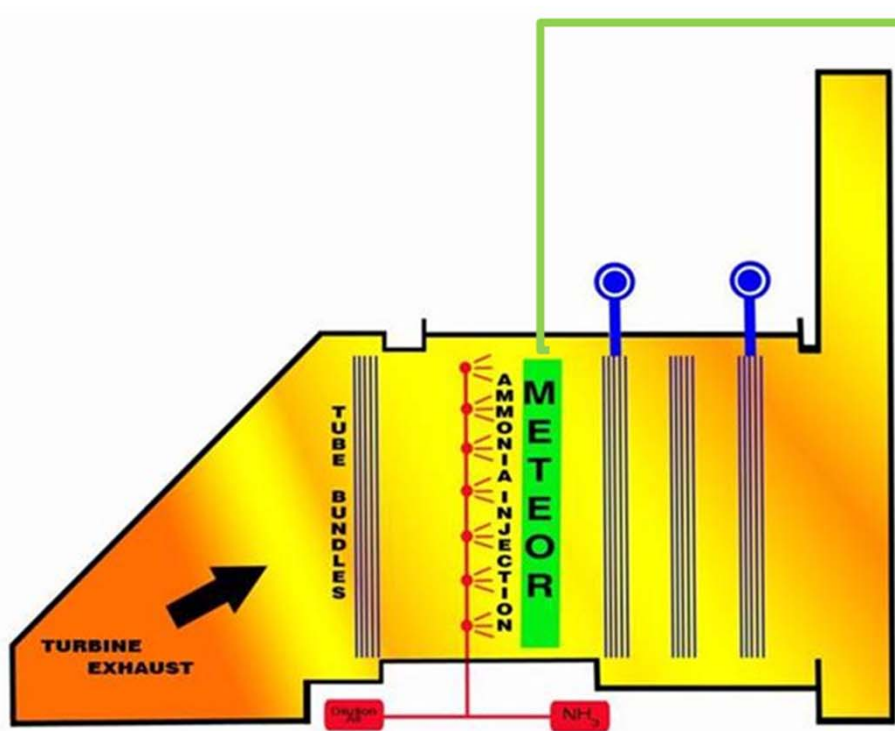
- Homogeneously extruded honeycomb catalyst (1 layer)
- **SCR** functionality \rightarrow V_2O_5 - WO_3 / TiO_2
- **Oxidation** functionality \rightarrow PGM (Pd and/or Pt)
- Initially developed and patented by **Siemens Energy** (US 7,390,471)
- Optimized and fully developed into commercial production by **Cormetech**



BACKGROUND

Single Layer HRSG Layout

→ AIG → METEOR™ MPC



Oxidizing Function:

CO oxidation to CO₂

VOC oxidation to CO₂ and H₂O

Reduction Function:



BACKGROUND

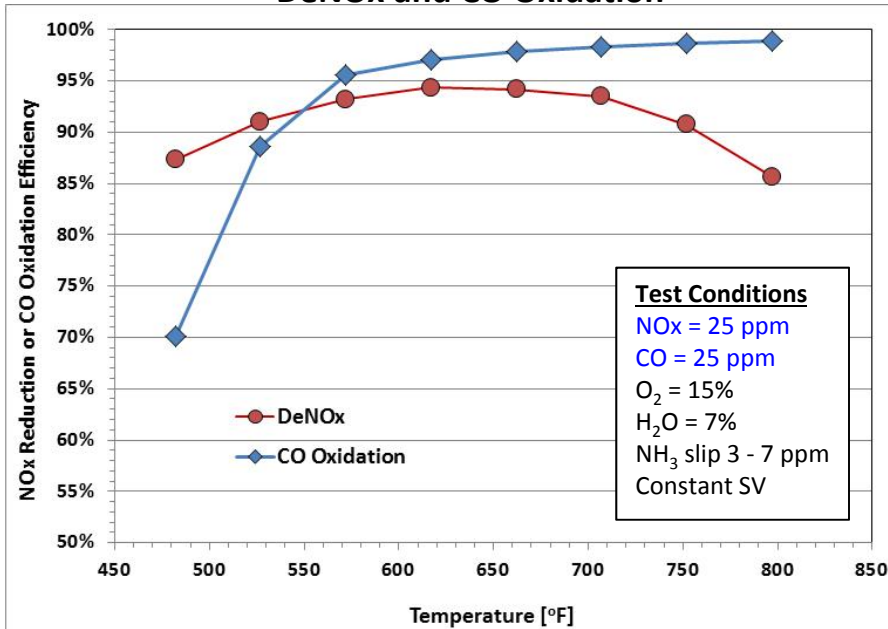
Example Lab-Reactor Data

METEOR™ MPC

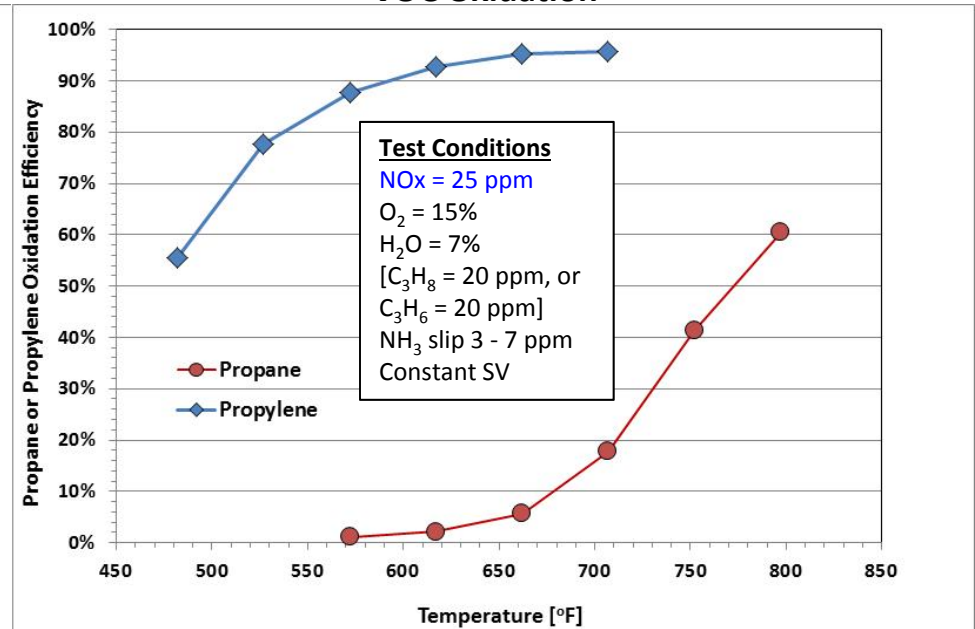


- **DeNOx and CO oxidation** → high conversion rates over wide temperature range.
- Active for **VOC oxidation** → rate depends on hydrocarbon speciation.
- **PGM loading** can be adjusted to optimize performance at low/high temperature.
- **Applications:** CCGT, SCGT, diesel/gas RE, refinery process units

DeNOx and CO Oxidation



VOC Oxidation



BACKGROUND

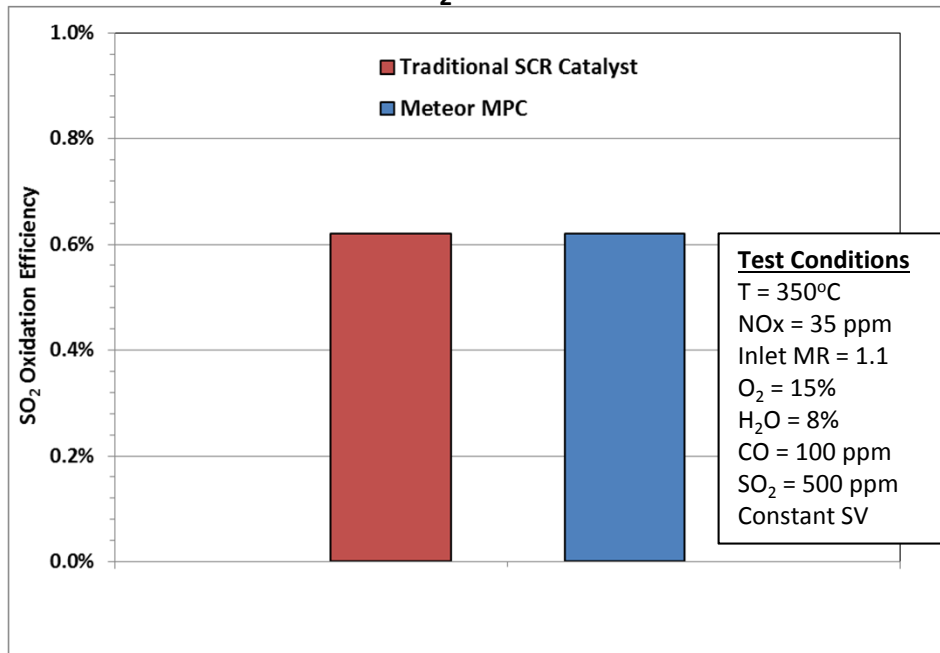
Example Lab-Reactor Data

METEOR™ MPC

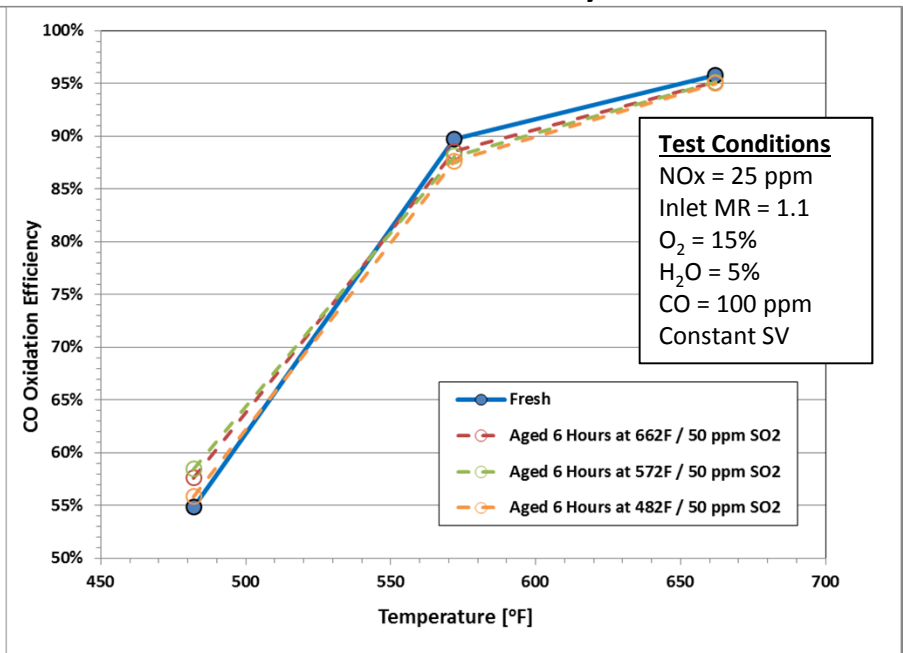


- **Similar** SO₂ oxidation rate as traditional SCR catalyst.
- Short-term exposure to **50 ppm SO₂** has **no significant impact** on CO oxidation.

SO₂ Oxidation



Sulfur Durability



BACKGROUND

Summary of Benefits

METEOR™ MPC



- **Simplicity:** *one catalyst layer vs. two.*
 - Smaller footprint in HRSG.
 - Lower pressure drop.
 - Lower capital and O&M costs.

- **Flexibility:** applicable to new units, retrofits, and replacements.

- **Lower SO₂ oxidation rate,** relative to the traditional two catalyst layout.
 - Potential for reduced backend fouling.

- **Highly resistant to sulfur** compounds in the flue gas.
 - Broader load flexibility from reduced sensitivity to sulfur fouling agents when operating at low temperature.

BACKGROUND

Financial Benefit of Reduced Pressure Drop METEOR™ MPC



- **Example:**
 - Reduced DP by 2" H₂O
- **Full load:**
 - Increased power sold.
- **Intermediate load:**
 - Lowered gas consumption.

Lower DP achieves tangible financial benefits.

Saving due to new pressure loss @ Full Load	
GT gross MW generated	240
Pressure drop reduction (inch H2O)	2
Natural Gas price \$/MMBtu	3
Catalyst guarantee (year)	5
Operating hours per year	4380
Annual gross power output MW	1051200
Price of electricity sold \$/MWh	30
Power output correction with correction curves for pressure drop	1.002
Total revenue for electricity sold	\$157,680,000
Total revenue for electricity sold with new pressure drop	\$157,995,360
Increase revenue from power sold over 5 years	\$315,360
Annual revenue increase from power sold/unit/year	\$63,072
Saving due to new pressure loss @ Intermediate Load	
GT gross MW generated	200
GT Gross Heat Rate Btu/kWh (HHV)	11500
Pressure drop reduction (inch H2O)	2
Natural Gas price \$/MMBtu	3
Catalyst guarantee (year)	5
Operating hours per year	3066
Heat rate correction with correction curves for pressure drop	0.9985
Total gas consumption	\$105,777,000
Total gas consumption corrected with new pressure drop	\$105,618,335
Gas consumption saving from improved heat rate over 5 years	\$158,666
Annual gas consumption saving/ unit/ year	\$31,733
Total net benefit over 5 years	\$474,026
Annual net benefit/unit/year	\$94,805

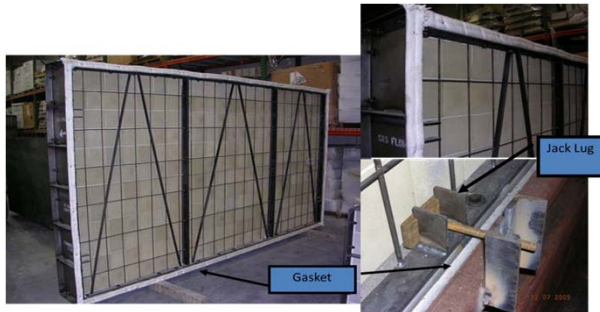
BACKGROUND

Module Options

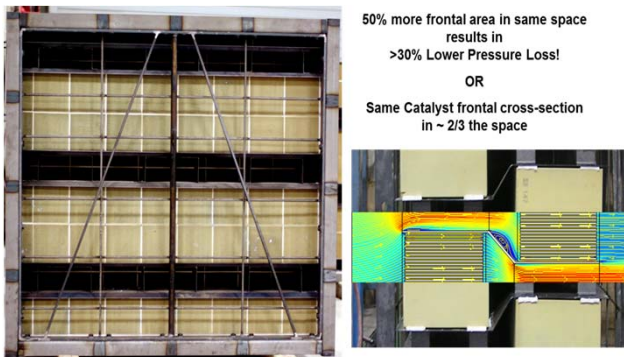
METEOR™ MPC



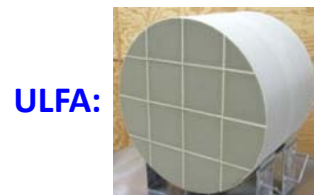
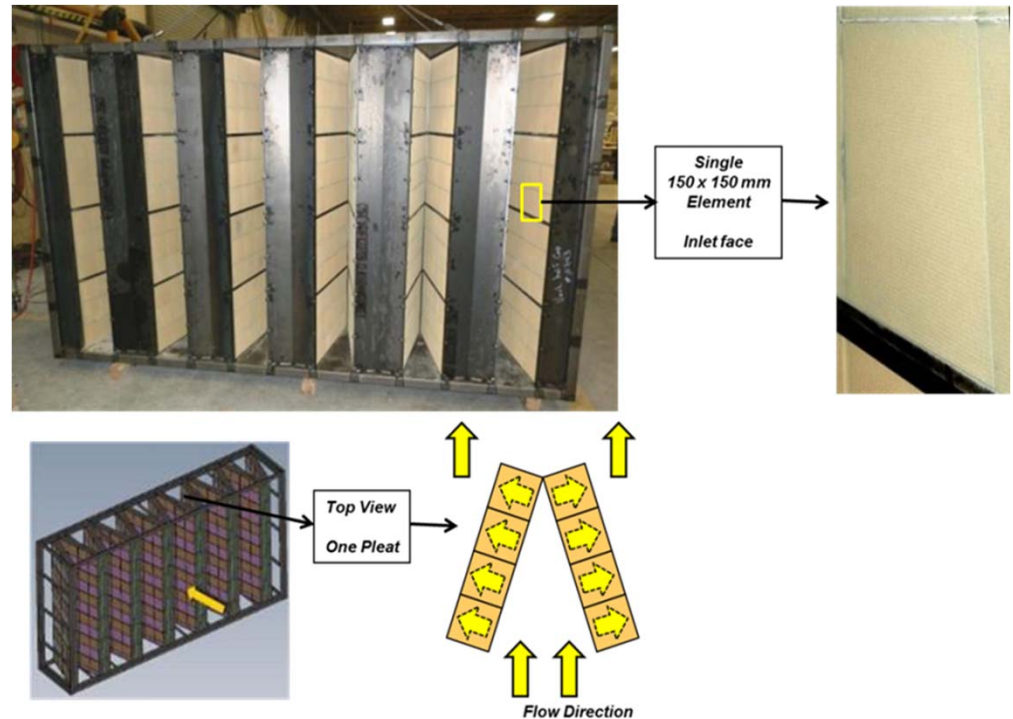
1 Traditional Horizontal Flow “Standard Module”



2 Patented “Advanced Module” for Gas-Fired SCR Units



4 Patent Pending “Elite™” Ultra-High Surface Area Module for Deeper Reduction in Pressure Drop for Gas-Fired SCR Units



METEOR™ MPC + ELITE™ Module = Optimal Low DP



Multi-Pollutant Catalyst (METEOR™ MPC)

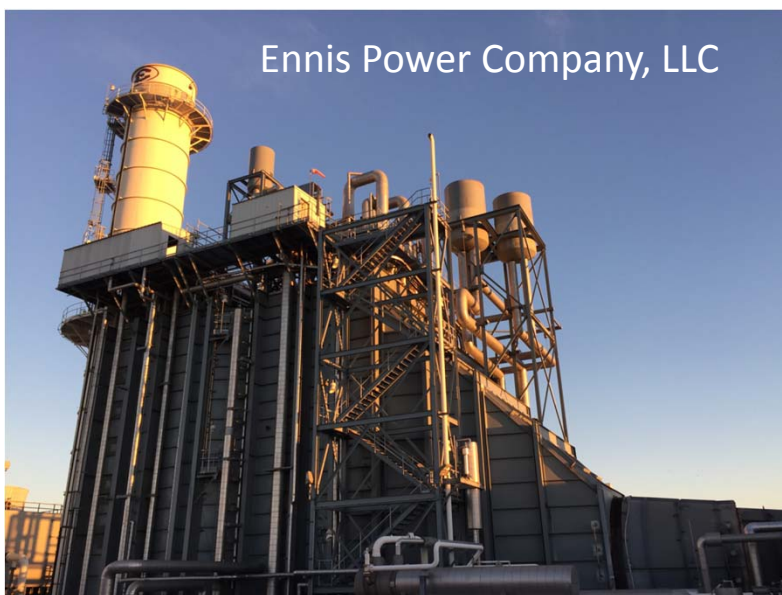
→ *Full-Scale Installation*

FULL-SCALE INSTALLATION

Ennis Power Company, LLC



- **Ennis Power Company, LLC (Ennis, Texas).**
- Siemens 501G unit combustion turbine (**340MW** combined cycle mode).
- **METEOR™ MPC / ELITE™** replaced existing SCR catalyst in November 2015.
- **Guaranteed emission reductions** of NO_x, NH₃ slip, CO and VOC.
- Successfully operating. Currently at >5,000 hours run time.



FULL-SCALE INSTALLATION

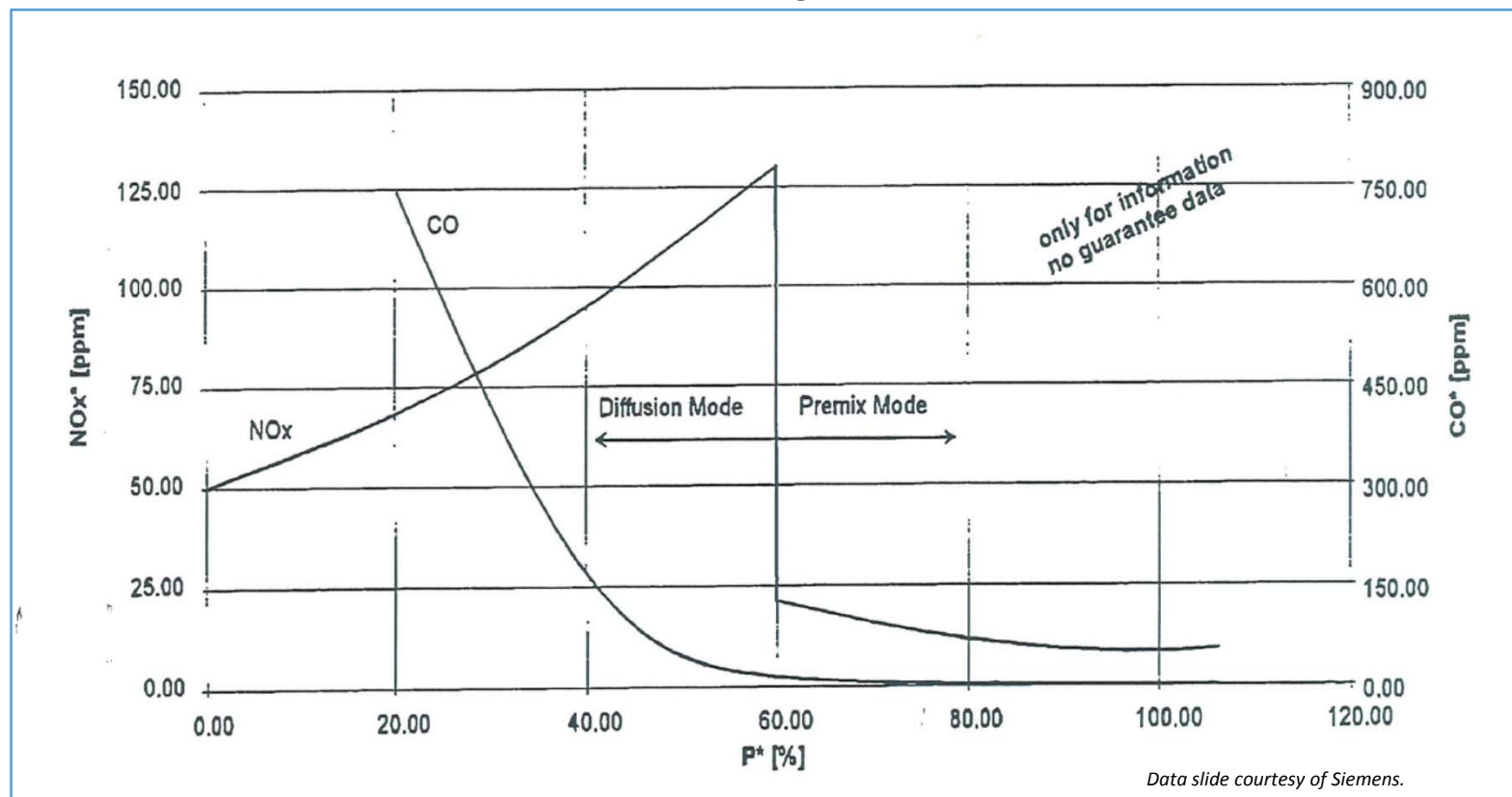
Ennis Power Company, LLC

Motivation



Replacement of existing SCR layer with a METEOR™ MPC catalyst layer enabled:

- (1) Capability to operate at lower loads while maintaining CO emission compliance.
- (2) Faster compliance of CO emissions during unit startup.



FULL-SCALE INSTALLATION

Ennis Power Company, LLC

Field Test Data (April 2016)



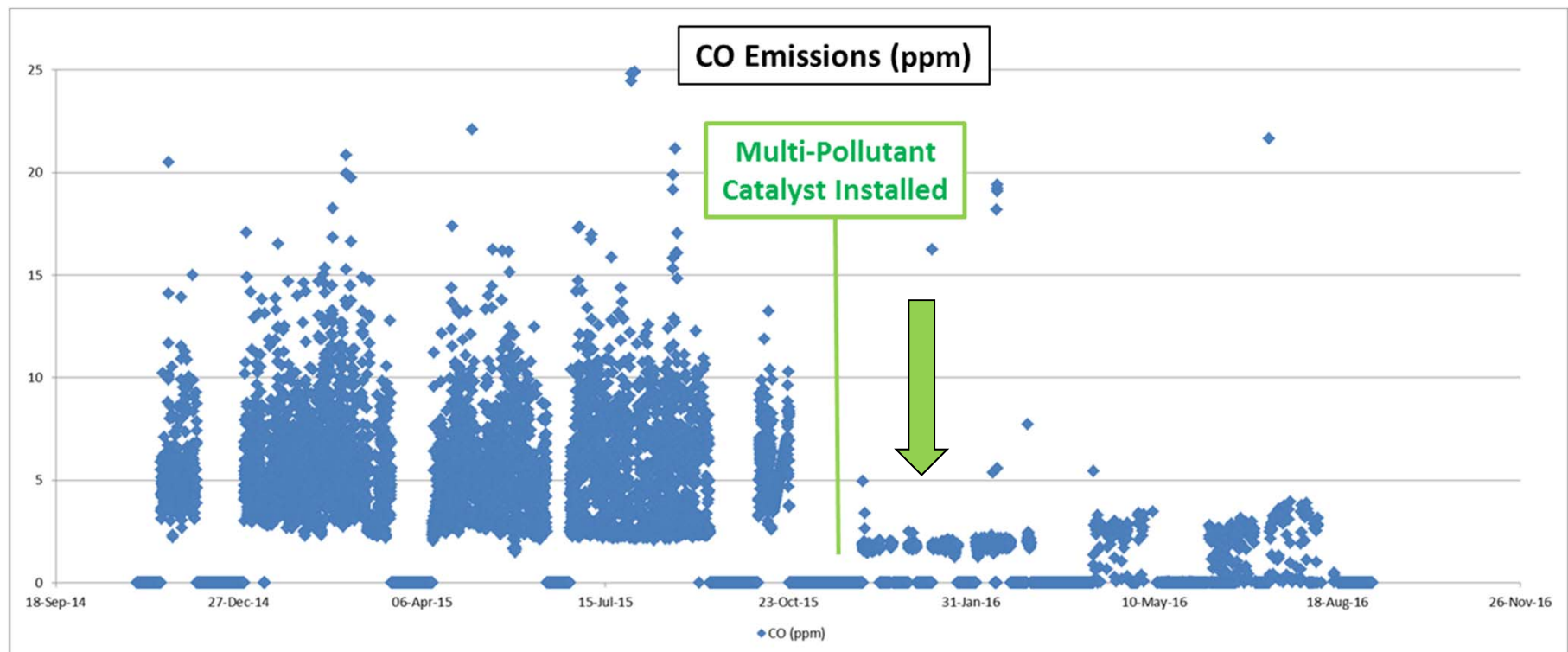
- **Field testing validation:** measured SCR inlet and outlet gas composition
 - SCR inlet = GT exhaust gas.
 - **Fresh catalyst achieved ~99% CO oxidation at 36% GT load point.**
 - DeNOx achieving target value. NH₃ slip is very low due to the fresh catalyst state.

		GT Exhaust Gas Composition		SCR Outlet Gas Composition		Meteor SCR Catalyst Performance		
GT Load	SCR Temperature (°C)	GT Exhaust CO (ppm)	GT Exhaust NOx (ppm)	SCR Outlet CO (ppm)	SCR Outlet NOx (ppm)	SCR CO Oxidation	SCR DeNOx	SCR Outlet NH ₃ Slip (ppm)
98%	342	0.5	29.4	0.0	7.8	100%	74%	0.7
76%	334	0.6	32.8	0.0	6.7	100%	80%	0.7
36%	322	172	44.0	2.2	6.7	98.8%	85%	0.5

FULL-SCALE INSTALLATION Ennis Power Company, LLC Plant Operating Data



- CO emissions reduced after METEOR™ MPC installed.



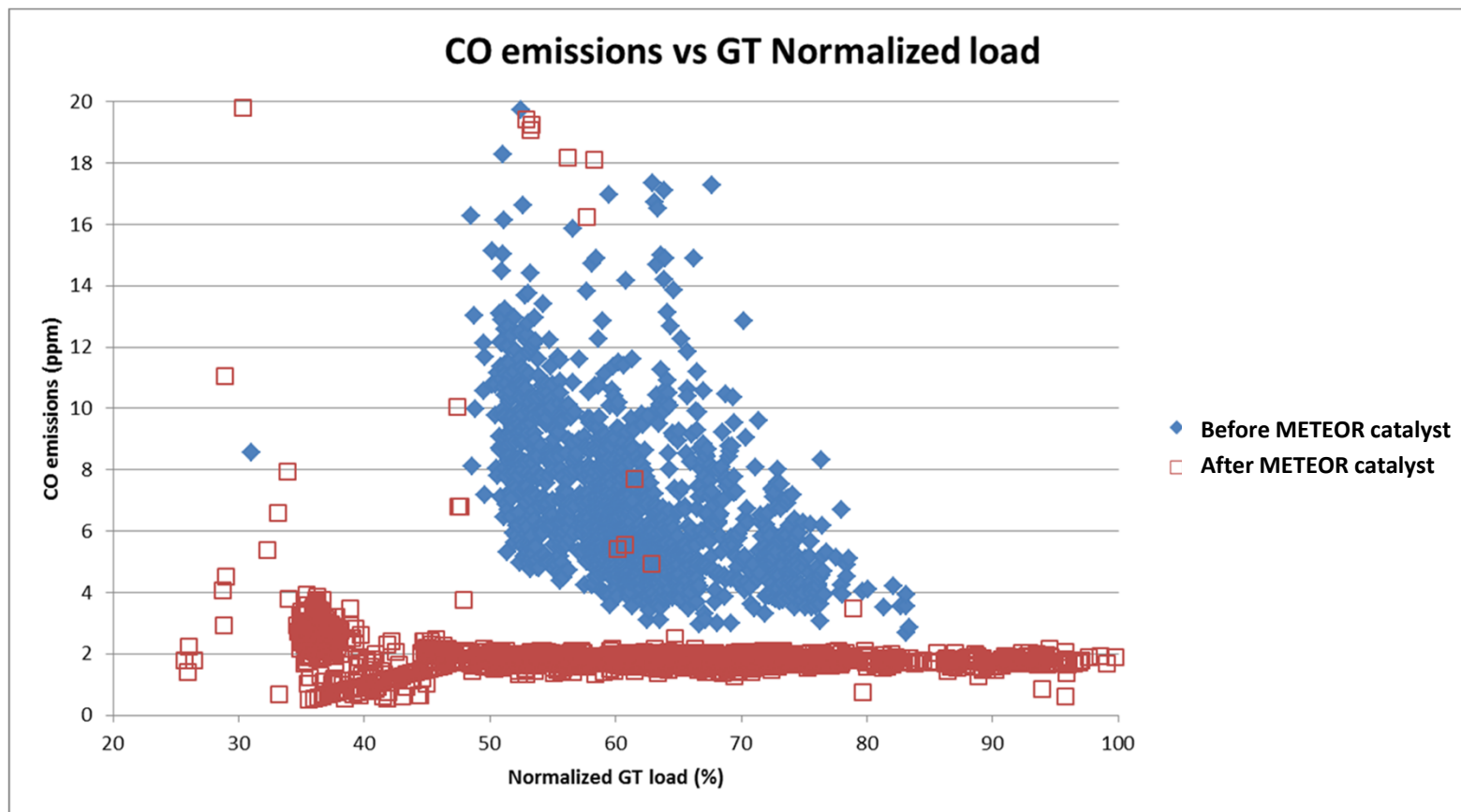
FULL-SCALE INSTALLATION

Ennis Power Company, LLC

Plant Operating Data



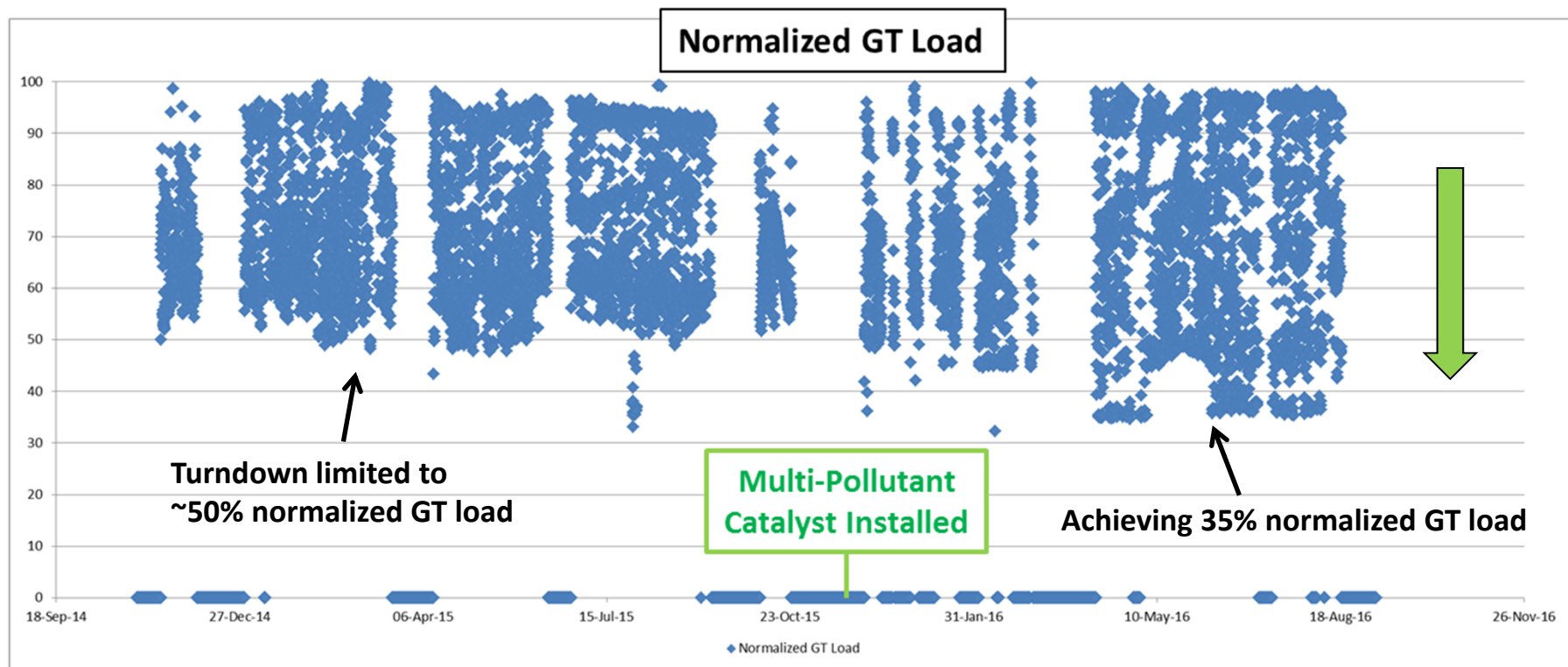
- **CO emissions vs. GT load: impact of METEOR™ MPC installation.**



FULL-SCALE INSTALLATION Ennis Power Company, LLC Plant Operating Data



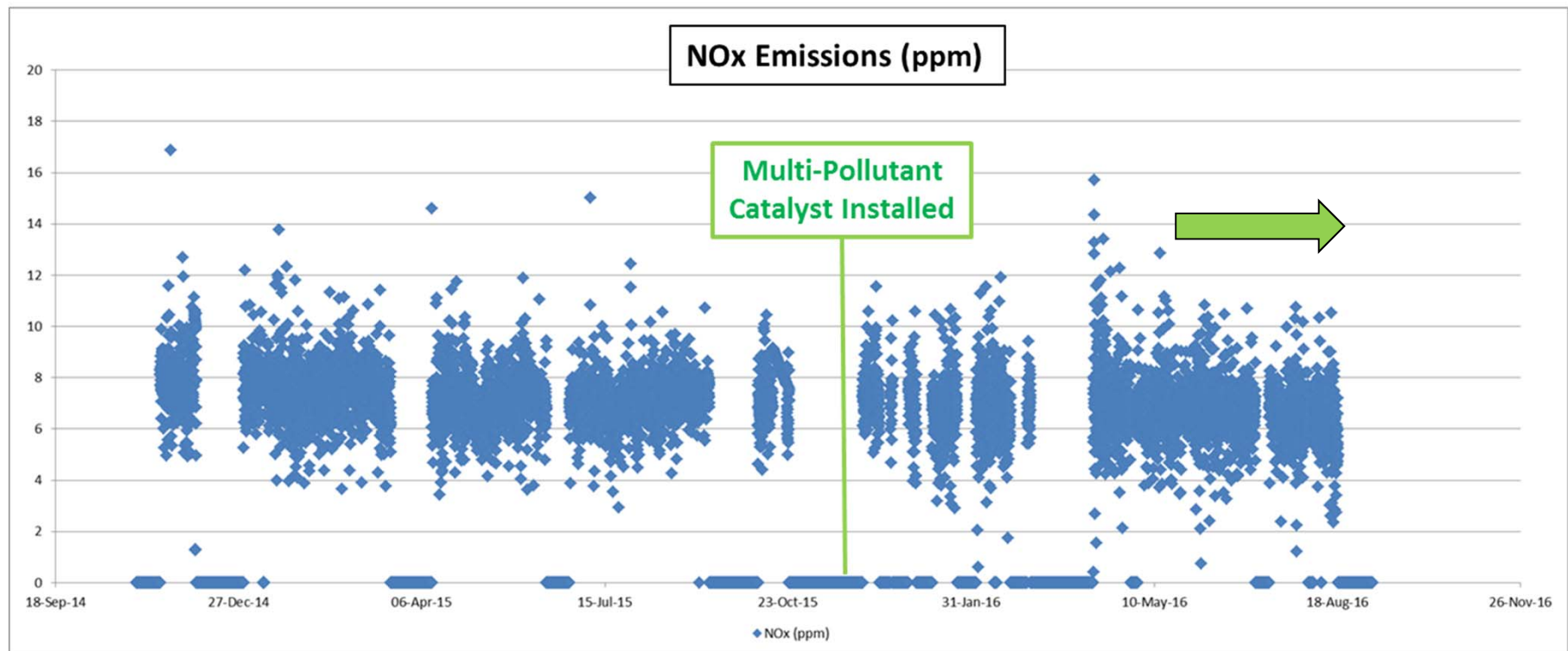
- METEOR™ MPC installation increased the unit's turndown capability.



FULL-SCALE INSTALLATION Ennis Power Company, LLC Plant Operating Data



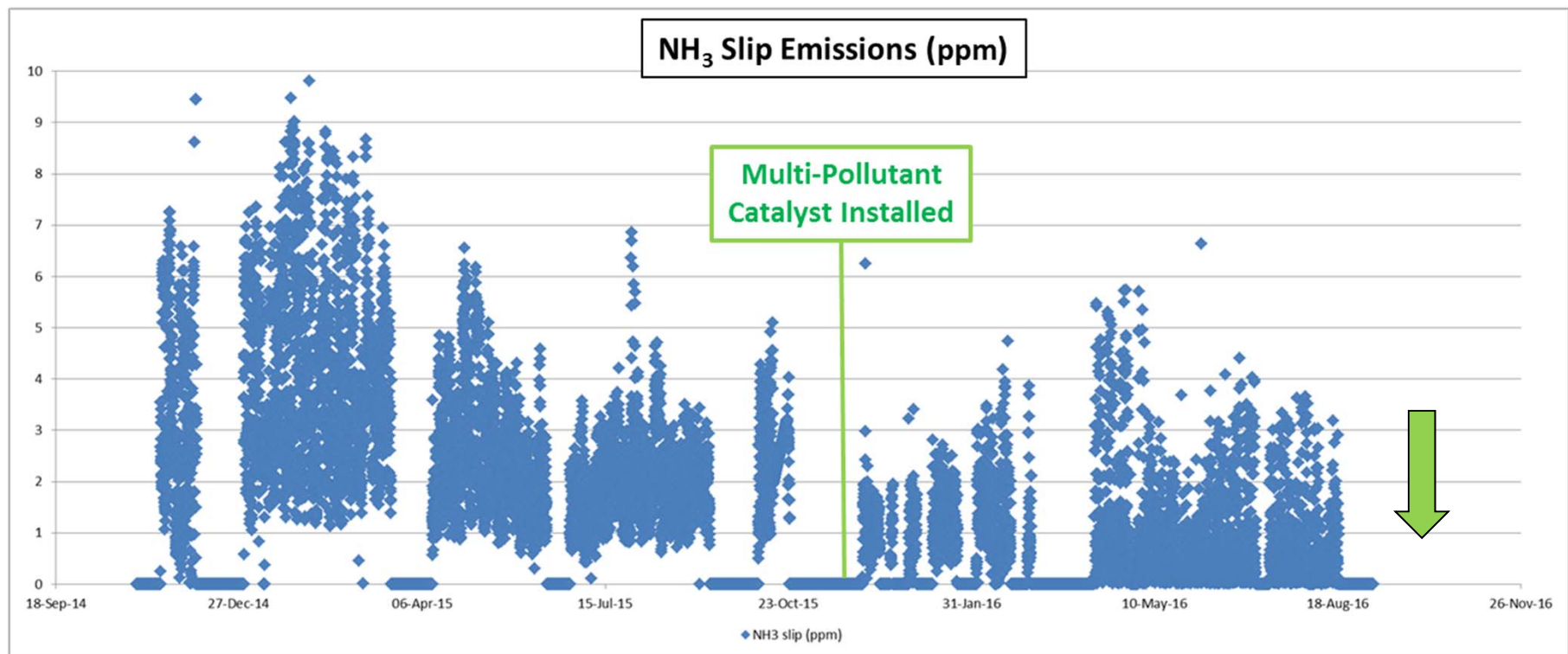
- Same NOx emissions (per design).



FULL-SCALE INSTALLATION Ennis Power Company, LLC Plant Operating Data



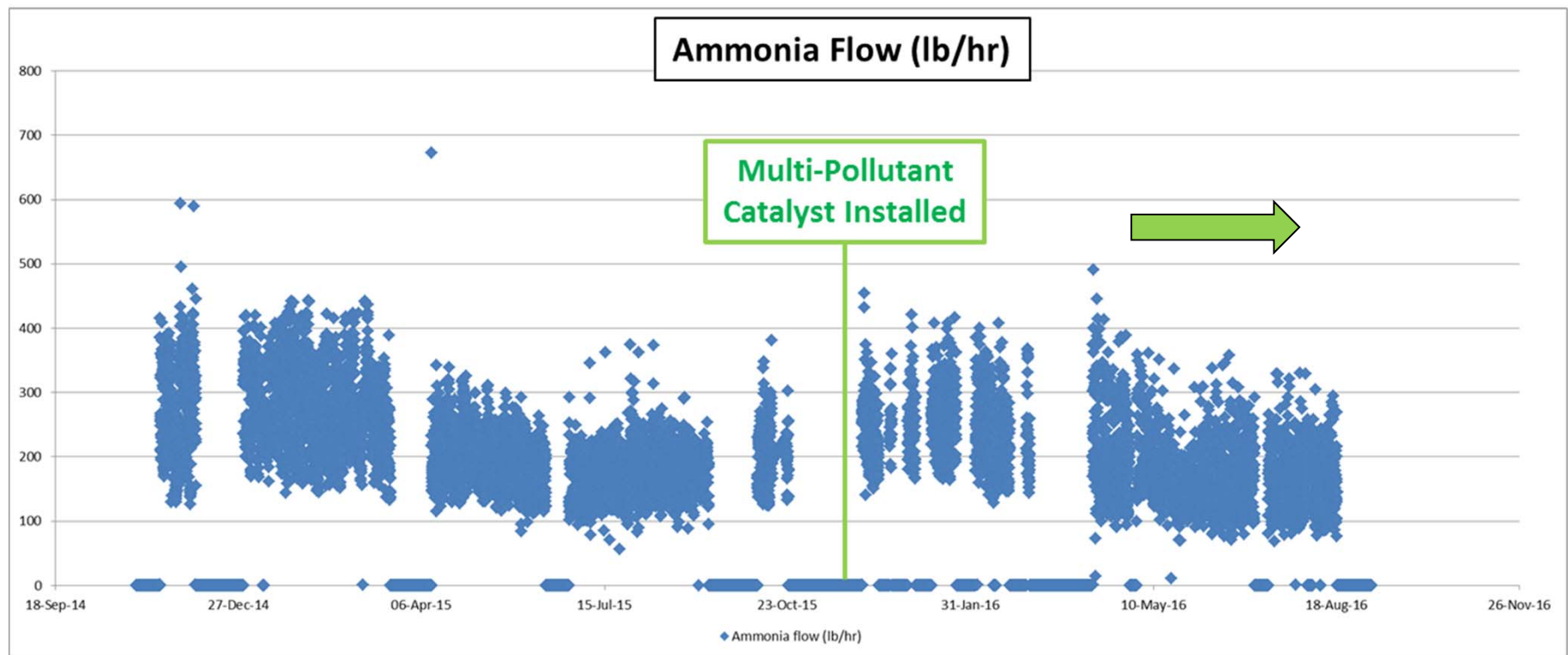
- Lower NH₃ slip emissions (fresh catalyst).



FULL-SCALE INSTALLATION Ennis Power Company, LLC Plant Operating Data



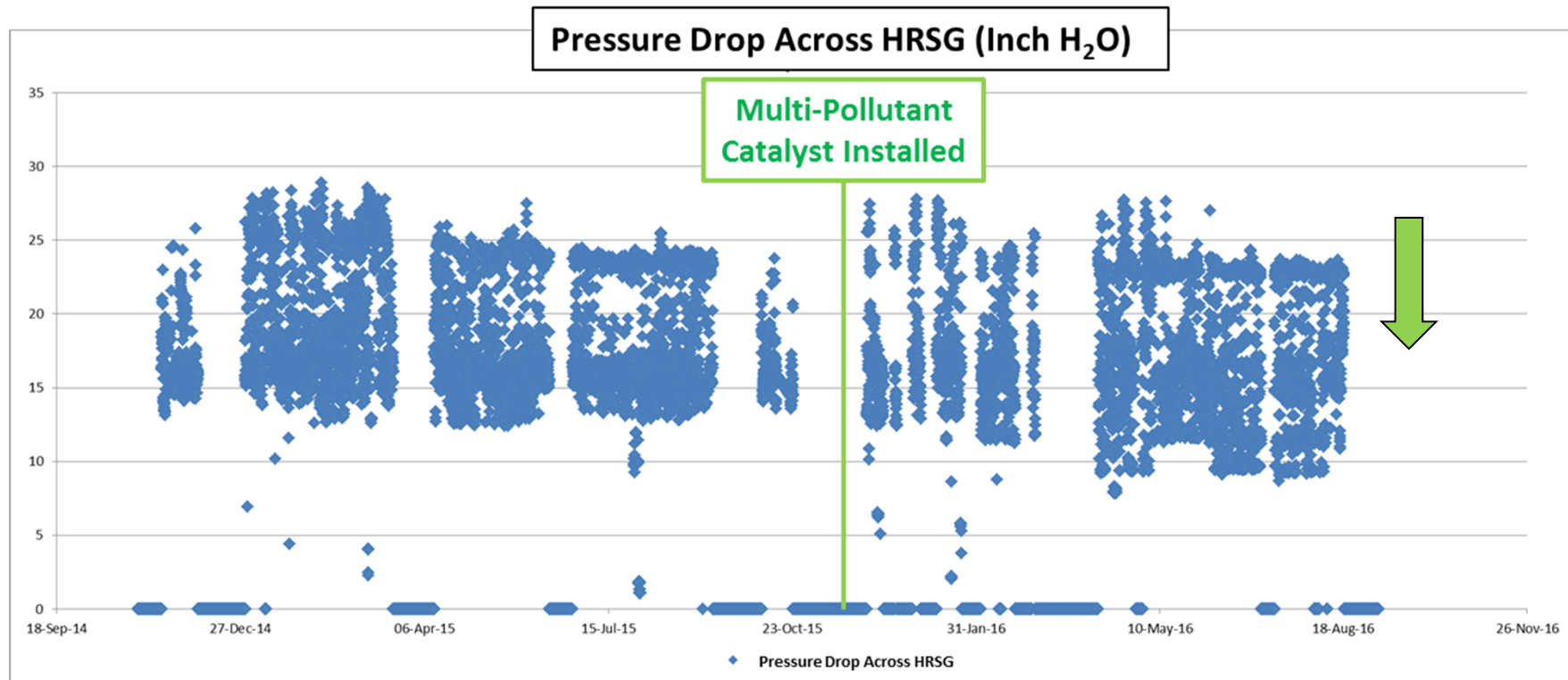
- No change in NH₃ usage rate after METEOR™ MPC installation.



FULL-SCALE INSTALLATION Ennis Power Company, LLC Plant Operating Data



- ~2 inch H₂O reduction in system backpressure (compared at constant flow)



FULL-SCALE INSTALLATION
Ennis Power Company, LLC
Catalyst Audit



Inspected catalyst on October 25, 2016:
The catalyst was in excellent condition,
and the cells were clean and open.
These observations are consistent with
the measured back pressure trends.



Inspection Photo
METEOR™ MPC in Ennis Power Company, LLC

Summary METEOR™ MPC

- **Simultaneously reduces** NO_x, CO, VOCs and NH₃ slip to compliance levels in one catalyst layer located at the traditional SCR catalyst location.
 - Lower system pressure drop.

- Provides **benefits**:
 - Total emissions regulation compliance.
 - Extended operating flexibility by extending the unit load operating range.
 - Reduction of corrosion of the HRSG section downstream of the SCR.
 - Lower O&M costs.

- **Applicable** to new units, retrofits, and replacements.

- **Successfully operating** at Ennis Power Company, LLC.

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Thank you for your attention!

See us at our PowerGen booth, send us an e-mail, or give us a call!

✓ **Cormetech, Inc.**

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