REINHOLD ENVIRONMENTAL ®

2022 Reinhold/PCUG Round Table Presentation

Hosted by Duke Energy in the Charlotte Sheraton/Le Meridien Hotel, Charlotte, NC on June 27-28, 2022

29th REINHOLD Round Table & Expo

Coal & Gas
Co-firing; Air Pollution Control
Waste Water Treatment

Implications of Hydrogen Firing in Combustion Turbines and Other "New Reality" Impacts

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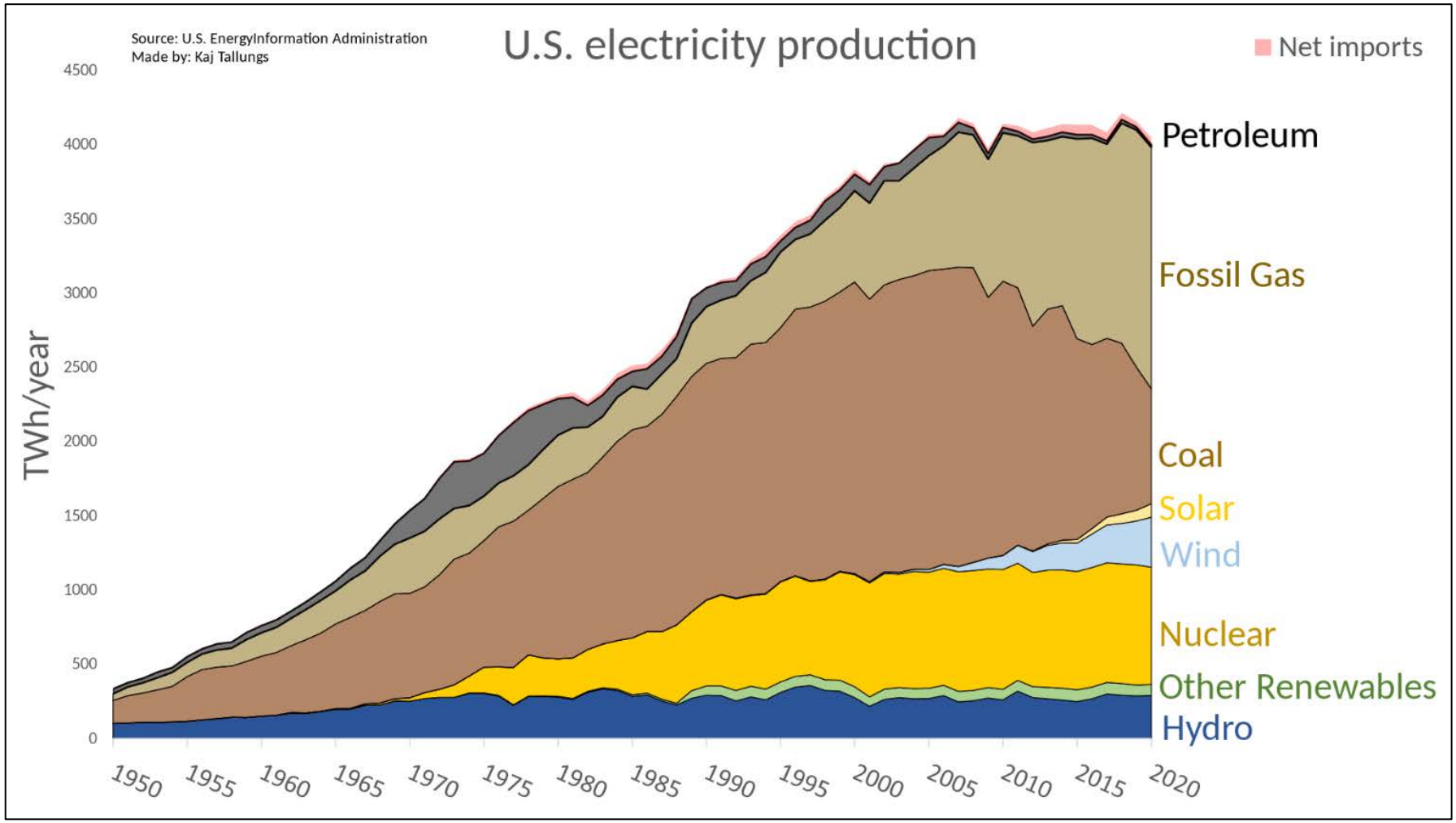
Presentation Overview

TODAY: ***CONVENTIONAL FUEL*** ***– challenges of operating gas-fired SCRs in a new generation environment***

TOMORROW: HYDROGEN FUEL – important implications for operating SCRs in future "green" landscape

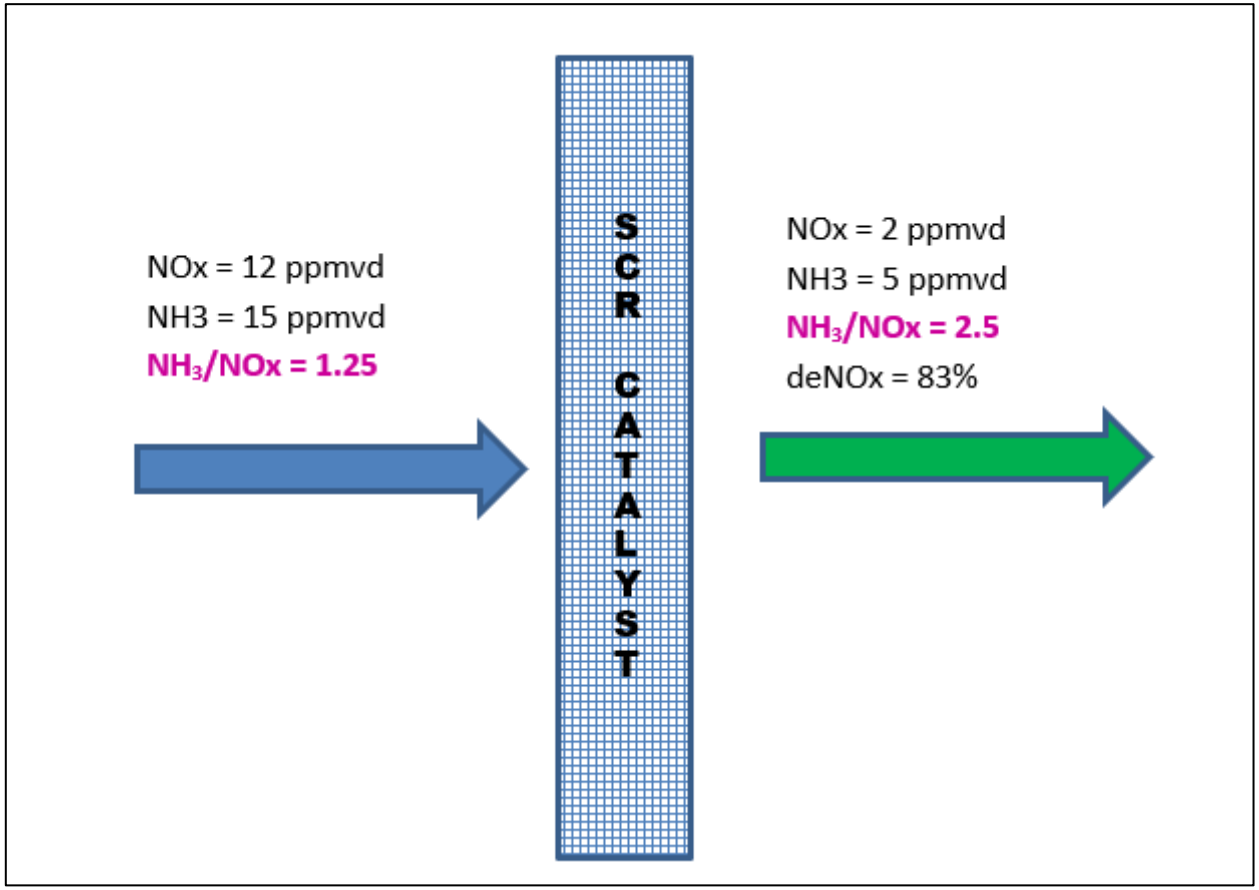
TODAY'S REALITY – GENERATION MIX



“BIG PICTURE” Operating Characteristics of CC SCRs

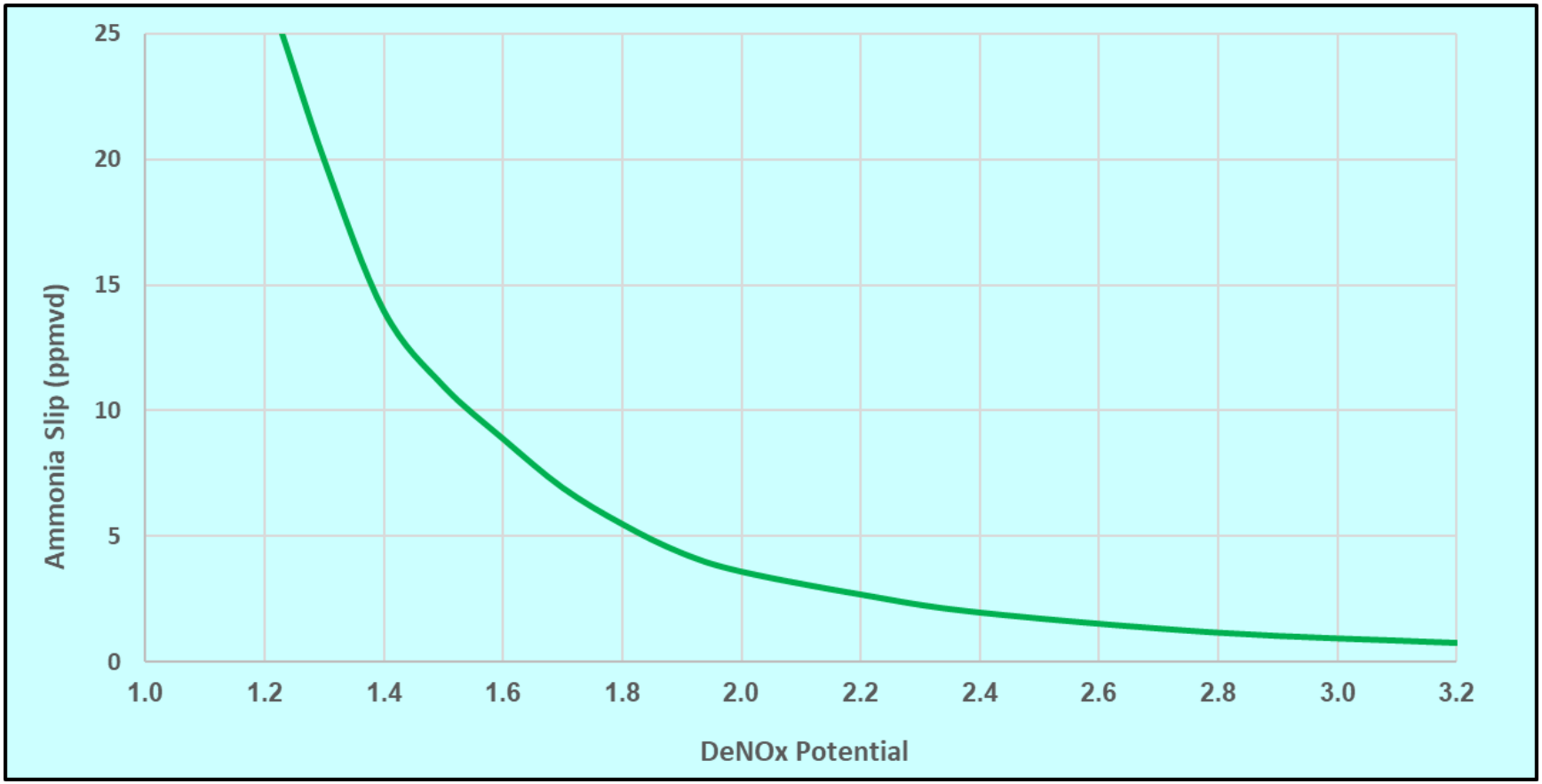
VERY HIGH LEVEL OF AMMONIA COMPARED TO NOx

EXAMPLE END-OF-LIFE CONCENTRATIONS



“BIG PICTURE” Operating Characteristics of CC SCRs

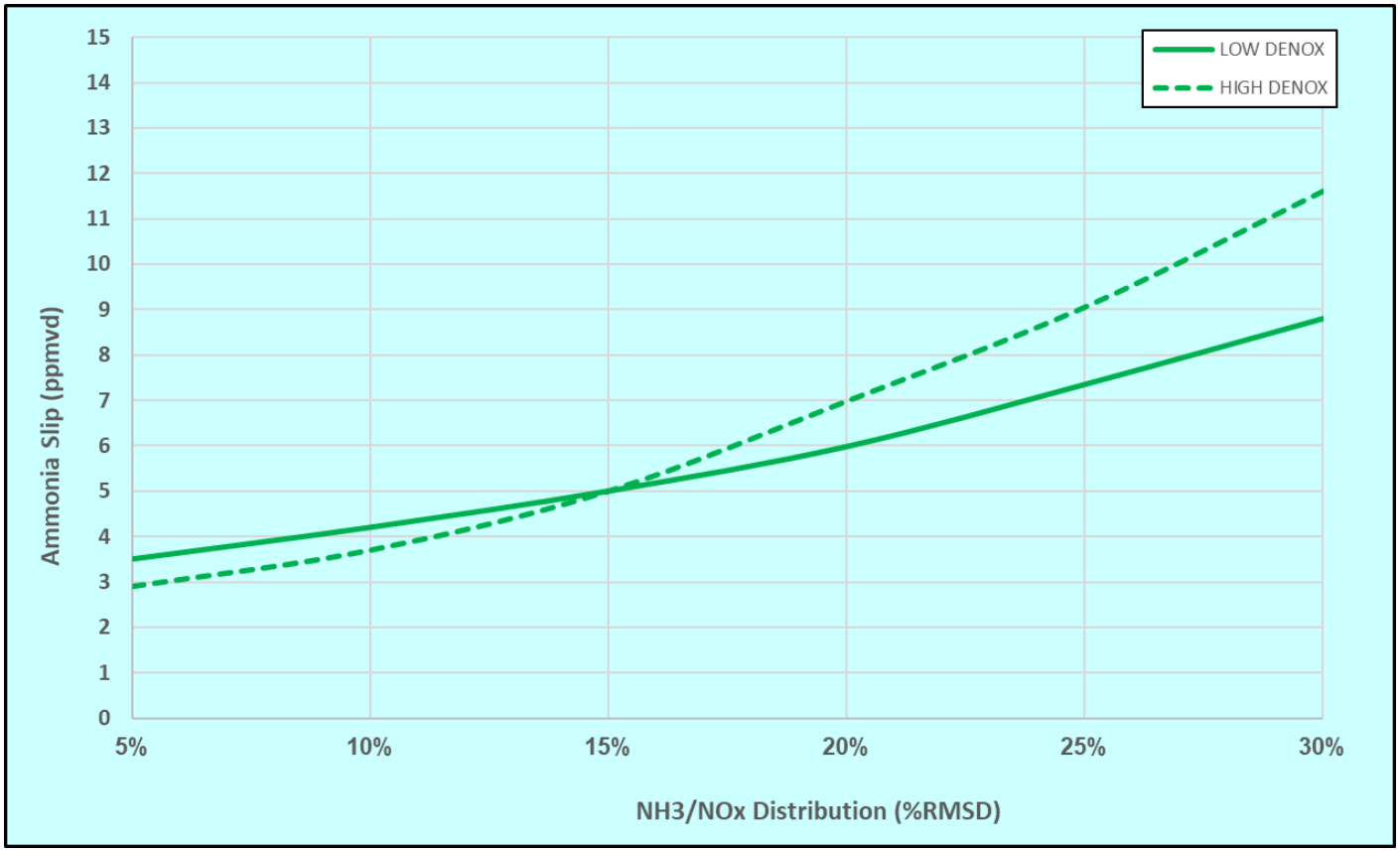
HIGH SENSITIVITY OF SLIP TO DeNOx POTENTIAL NEAR END-OF-LIFE



Assumptions/Constants		
Inlet NOx	12	ppmvd
Outlet NOx	2	ppmvd
DeNOx	83.3%	

"BIG PICTURE" Operating Characteristics of CC SCRs

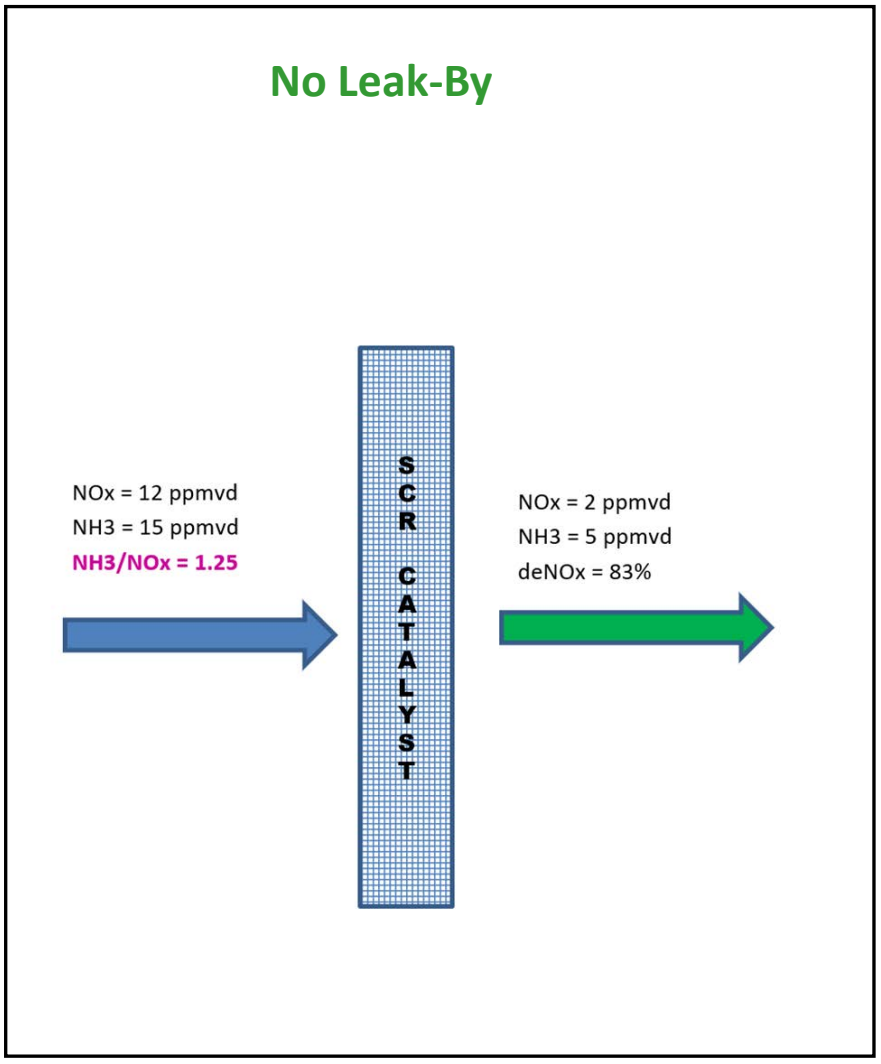
SENSITIVITY OF SLIP TO NH_3/NOx DISTRIBUTION

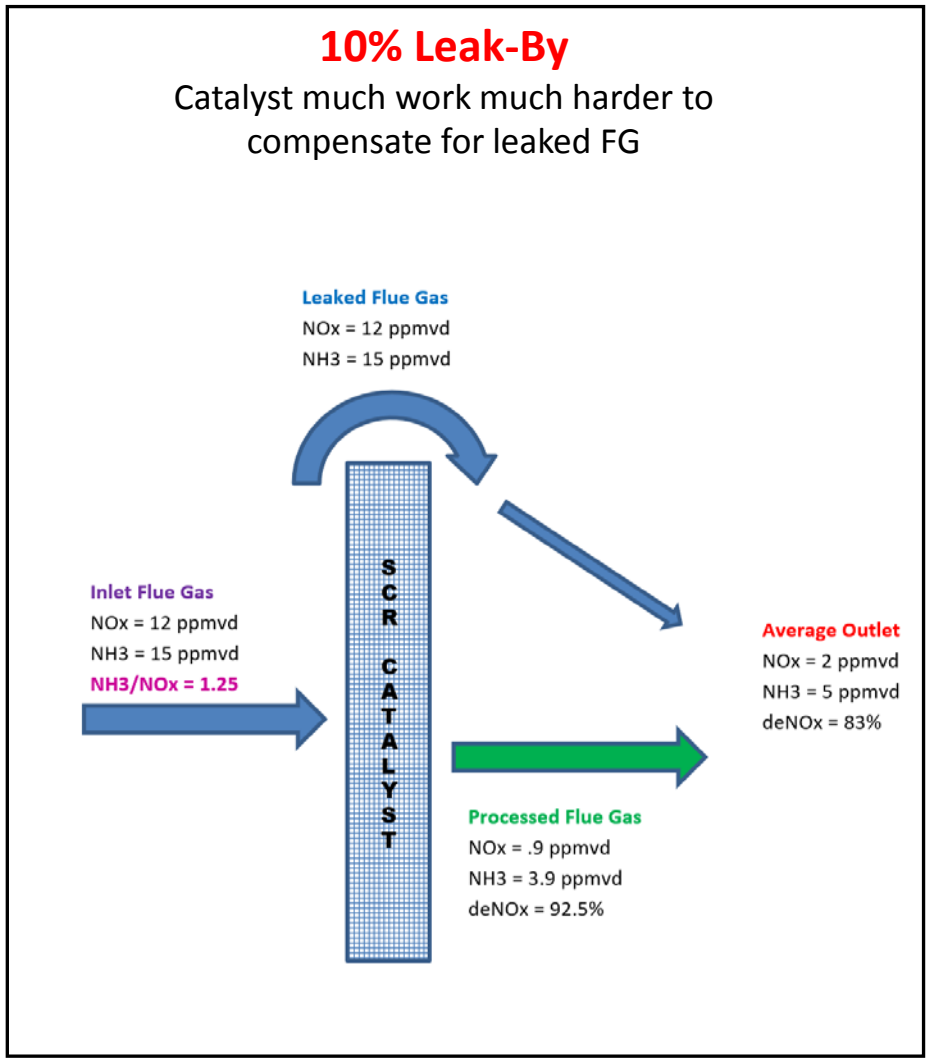


LOW DENOX		
Assumptions/Constants		
Inlet NOx	12	ppmvd
Outlet NOx	2	ppmvd
DeNOx	83.3%	
Pmin	1.84	
Design Slip	5	ppmvd
Design NH3/NOx Dist.	15%	RMSD

HIGH DENOX		
Assumptions/Constants		
Inlet NOx	15	ppmvd
Outlet NOx	1.5	ppmvd
DeNOx	90.0%	
P	2.43	
Design Slip	5	ppmvd
Design NH3/NOx Dist.	15%	RMSD

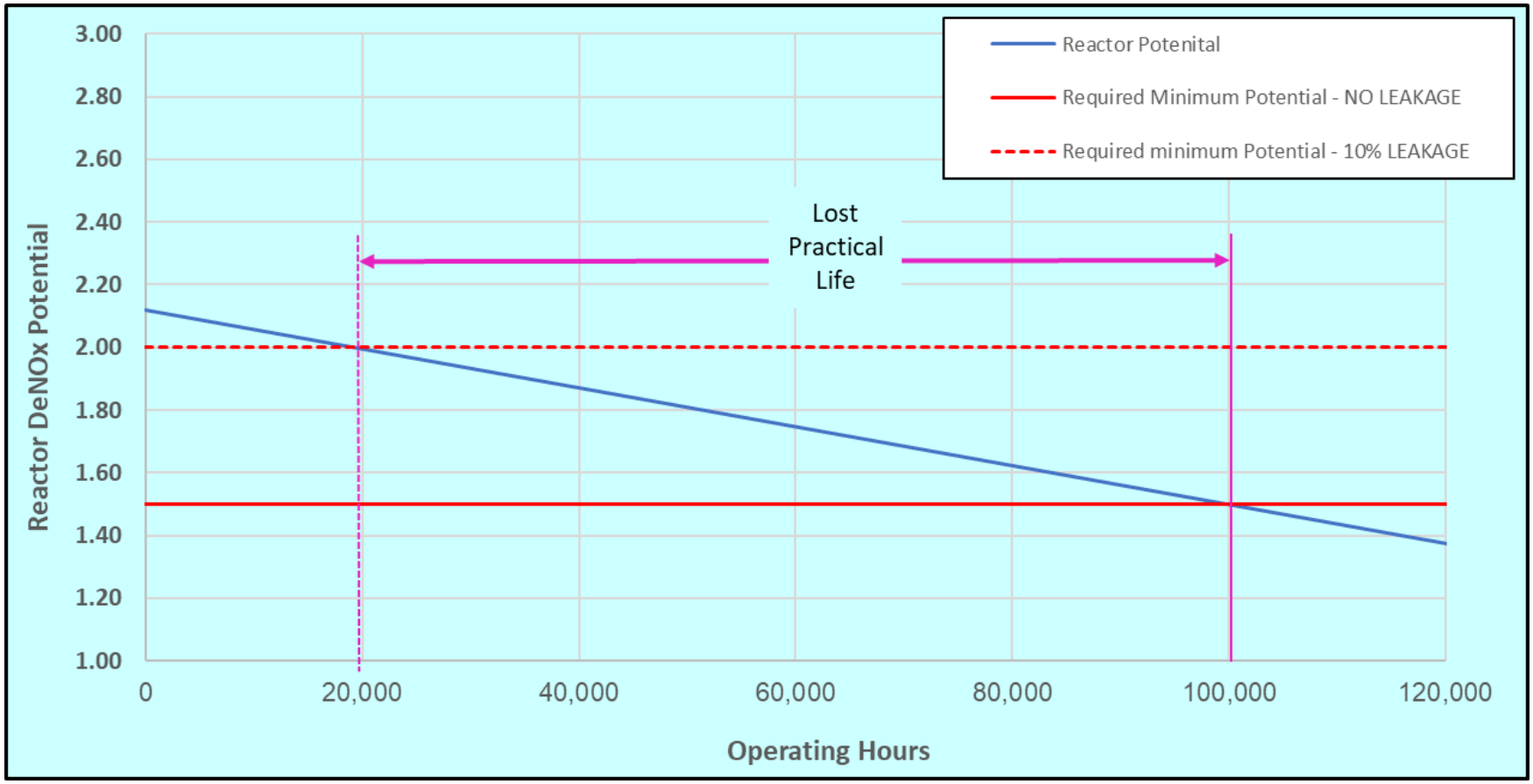
CC Units Not Immune to SCR Problems: LEAK-BY





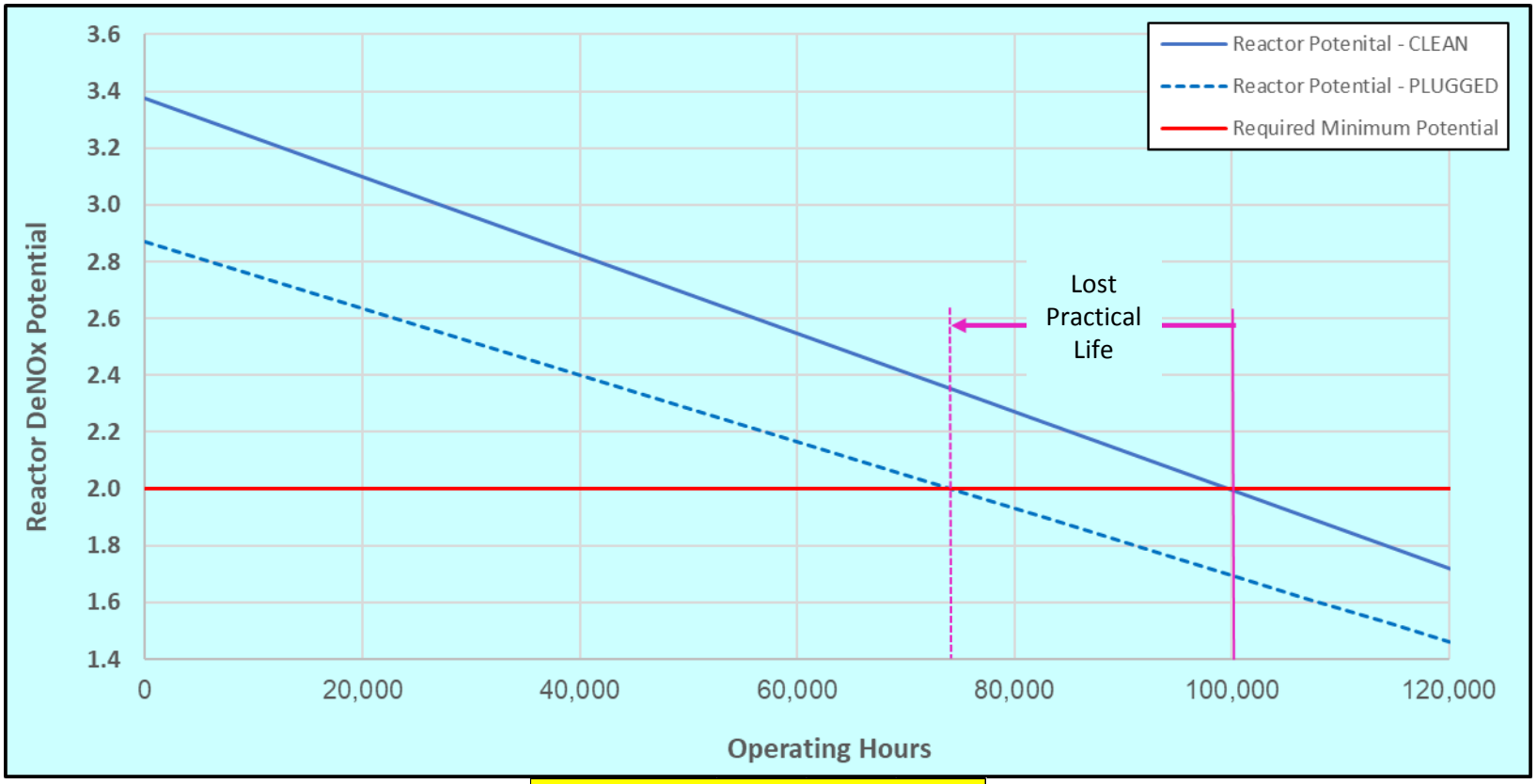
Leak-By Life Effect

Life effect using previous slide assumptions (maintain 83% deNOx), with nominal Po and deactivation.



CC Units Not Immune to SCR Problems: PLUGGING

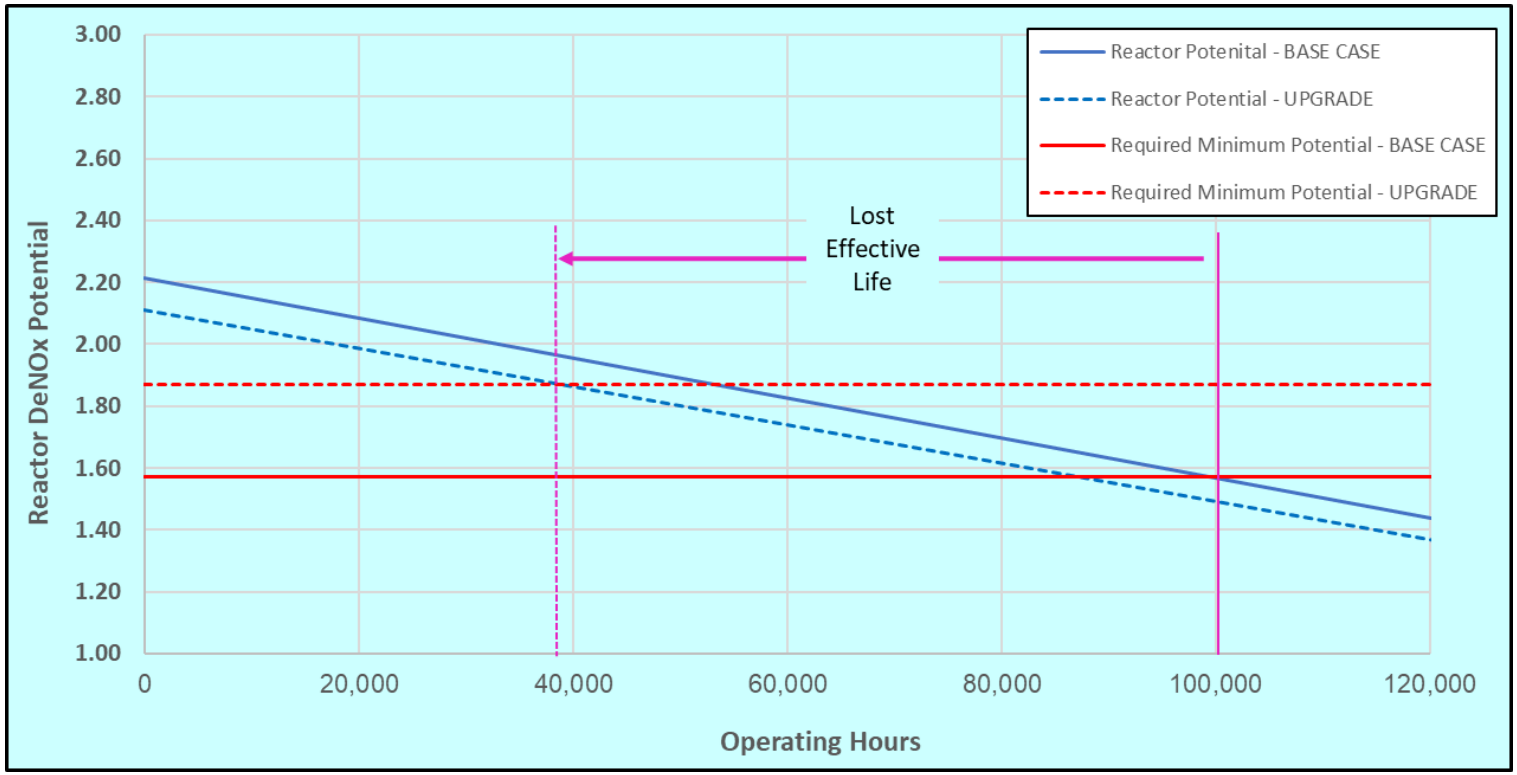
Example Effect: Plugging removes catalyst from service, has effect of lowering available deNOx potential.



Assumptions		
CT NOx Production	0.05	lb/MMBtu
Inlet NOx	13.81	ppmvd at 15% O2
Outlet NOx	2	ppmvd at 15% O2
DeNOx	85.5%	
Slip	5	ppmvd at 15% O2
Pmin	2.0	
Plugging Level	15%	

UPGRADE EFFECTS

Upgrades can affect both Pmin and Actual Reactor Potential.
This example is for increase in inlet NOx, increase in deNOx, and increase in flow rate.



Assumptions			
	Base	Upgrade	
Inlet NOx	12	15	ppmvd at 15% O2
Outlet NOx	2	2	ppmvd at 15% O2
DeNOx	83.3%	86.7%	
Slip	10	10	ppmvd at 15% O2
Normalized Flow	1.00	1.05	
Pmin	1.57	1.87	

Increased flow lowers actual reactor deNOx potential.

Increased inlet NOx raises deNOx, and in turn raises required minimum potential.

HYDROGEN FIRING

What will be the performance of CTs firing Hydrogen?

- MW Output
- Efficiency
- Emissions

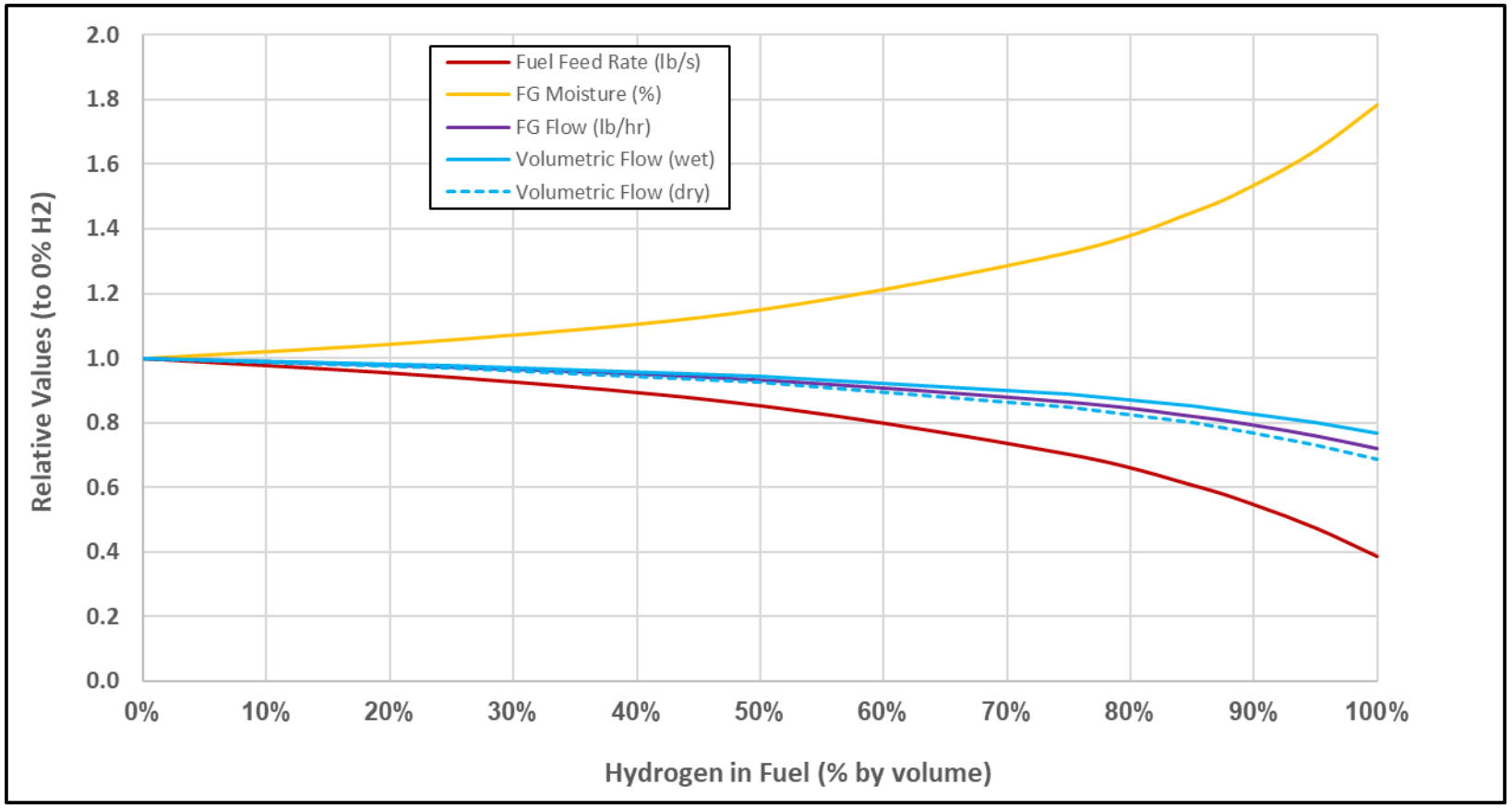
How will SCR and CO catalysts/systems be affected?

- Will change in flue gas constituents affect activity? (moisture, excess O_2, etc.)
- How will potential changes in NO/NO_2 affect deNOx?
- Will current permits/regulations change?

HYDROGEN BLENDING EFFECTS ON FLUE GAS PRIMARY PARAMETERS

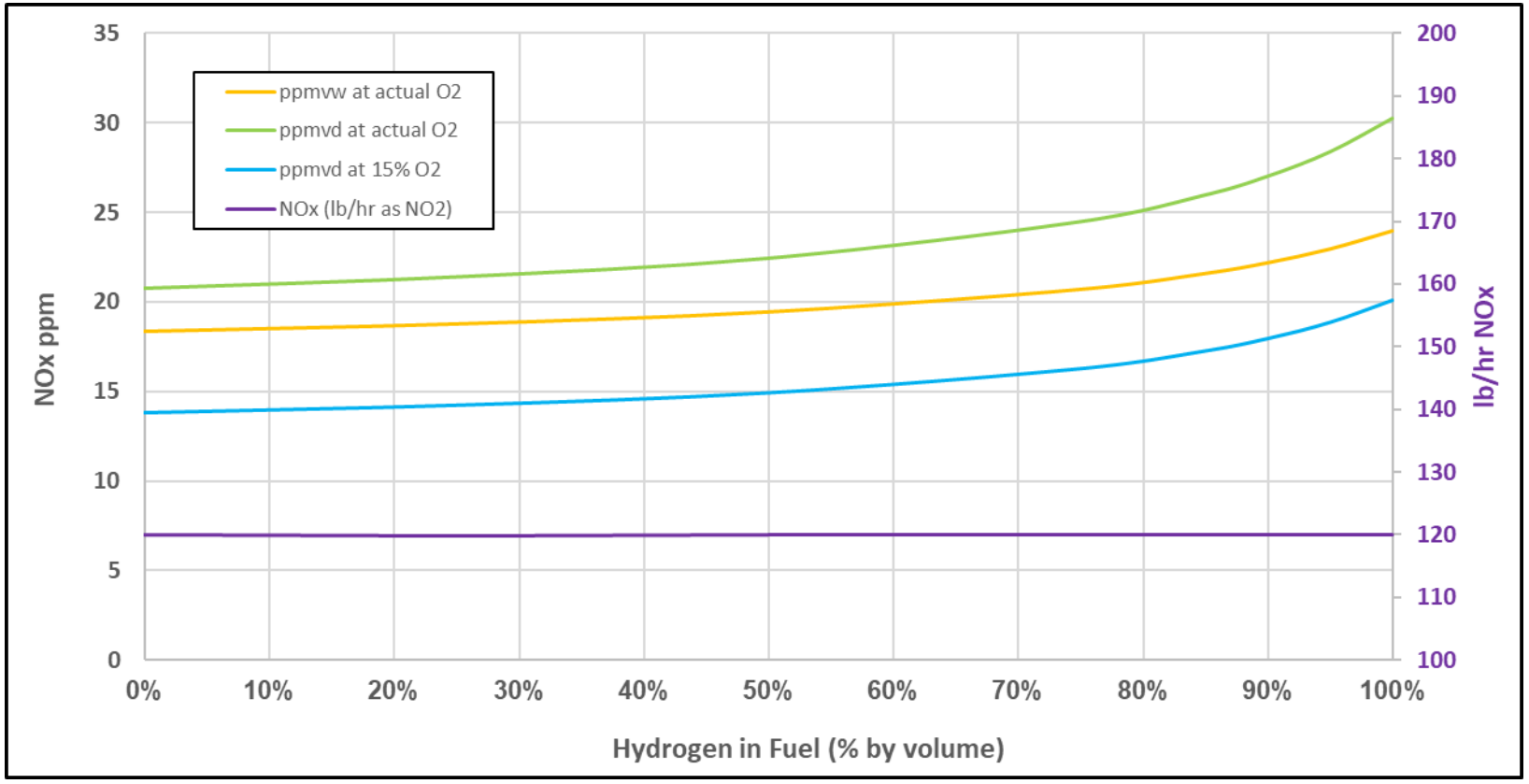
Assume excess O_2 (12%), and heat input are constant regardless of H_2 bend ratio.

These may or may not be good assumptions!



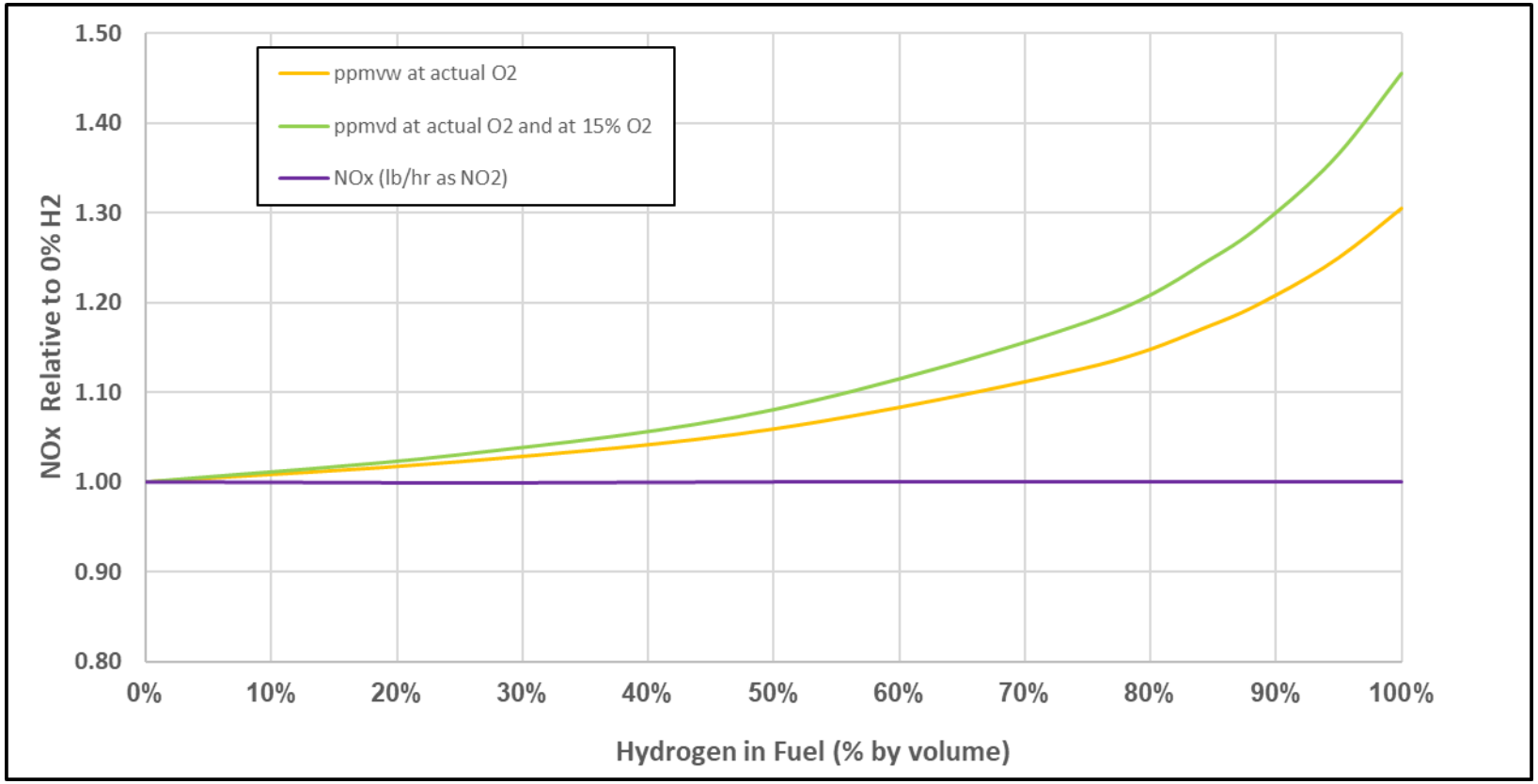
HYDROGEN BLENDING EFFECTS ON FLUE GAS NOx CONCENTRATIONS

Assume excess O2 constant at 12%, and NOx at 0.05 lb/MMBtu, constant heat input.



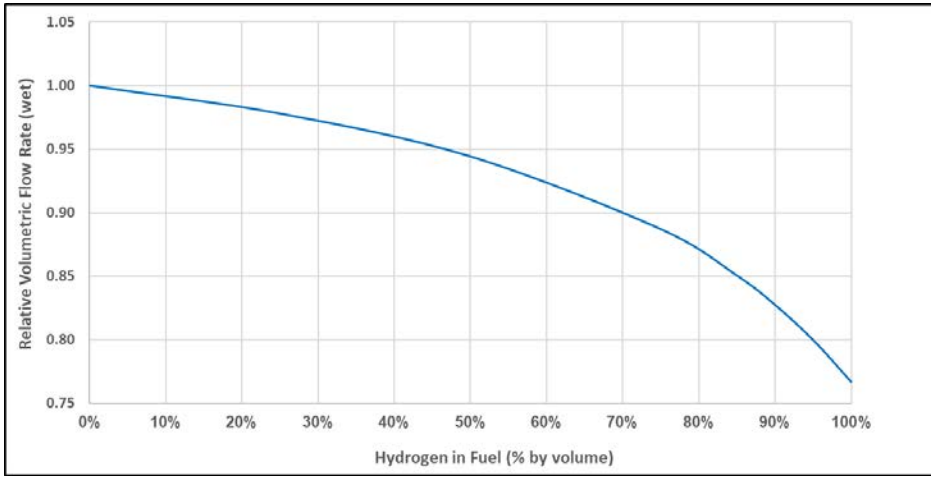
HYDROGEN BLENDING EFFECTS ON FLUE GAS RELATIVE NOx CONCENTRATIONS

Assume excess O2 constant at 12%, and NOx at 0.05 lb/MMBtu, constant heat input.

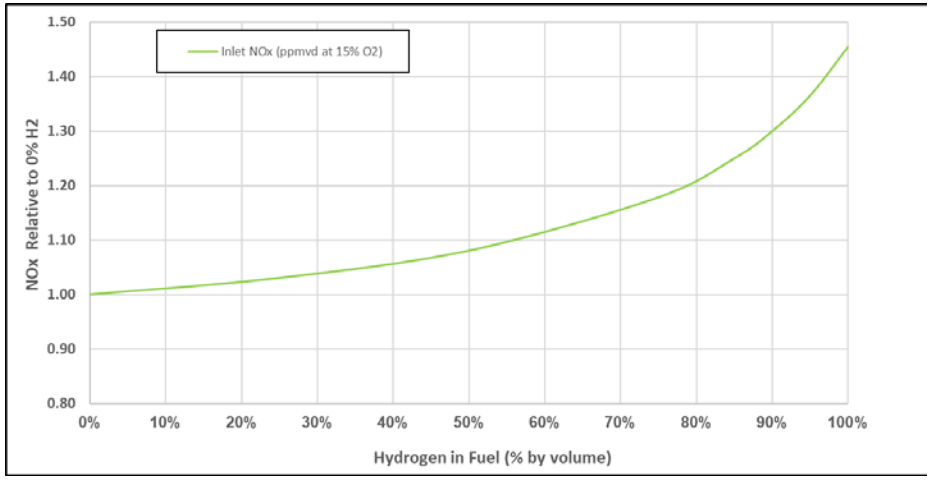


EXAMPLE HYDROGEN EFFECT ON SCR MARGIN: Two offsetting effects

Decreased volumetric flow raises actual reactor deNOx potential (P=K/AV, Flow ⬇, AV ⬇, P ⬆)

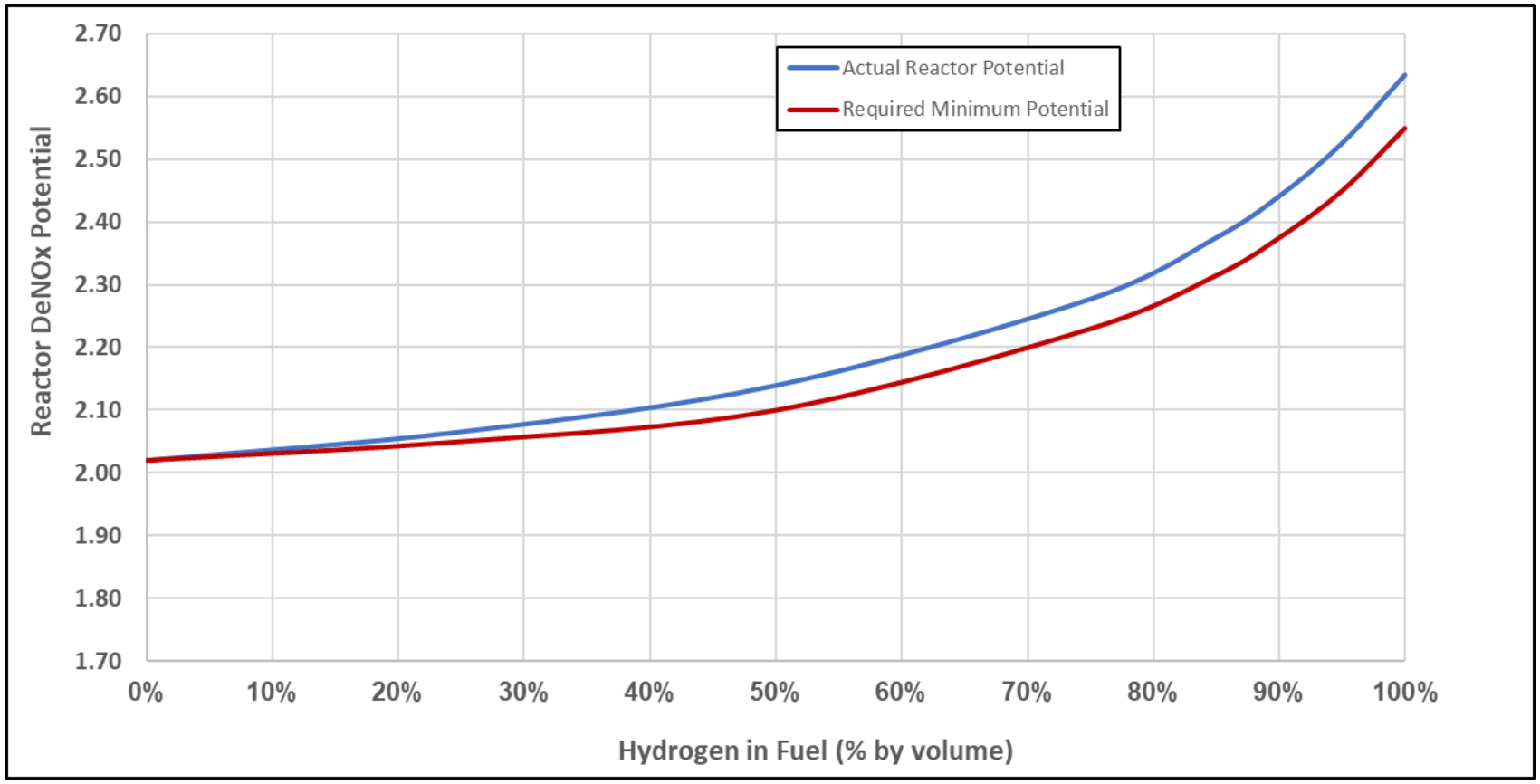


Increased SCR inlet NOx raises minimum deNOx potential when holding slip constant on ppmvd at 15% O_2 basis.



Uses previous slide assumptions

EXAMPLE HYDROGEN EFFECT ON SCR MARGIN: Two offsetting effects



Uses previous slide assumptions

Additional Information

Proceedings of ASME Turbo Expo 2022
Turbomachinery Technical Conference and Exposition
GT2022
June 13-17, 2022, Rotterdam, The Netherlands

GT2022-80971

POLLUTANT EMISSIONS REPORTING AND PERFORMANCE CONSIDERATIONS FOR HYDROGEN–HYDROCARBON FUELS IN GAS TURBINES

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Gas turbines in a carbon-neutral society
10th International Gas Turbine Conference
11-15 October 2021

Paper ID Number: 7-IGTC21

HYDROGEN CAPABILITIES OF SIEMENS ENERGY GAS TURBINES, AN OEM PERSPECTIVE

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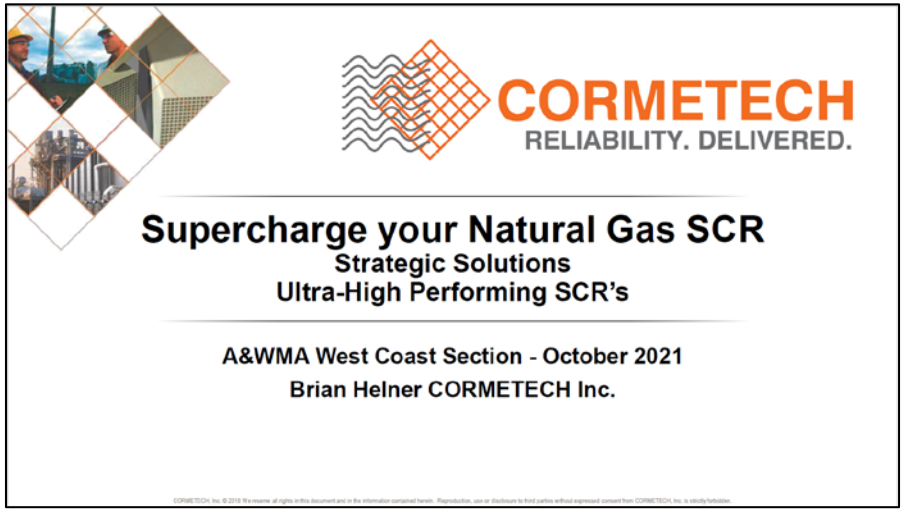
Additional Information



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