

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

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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

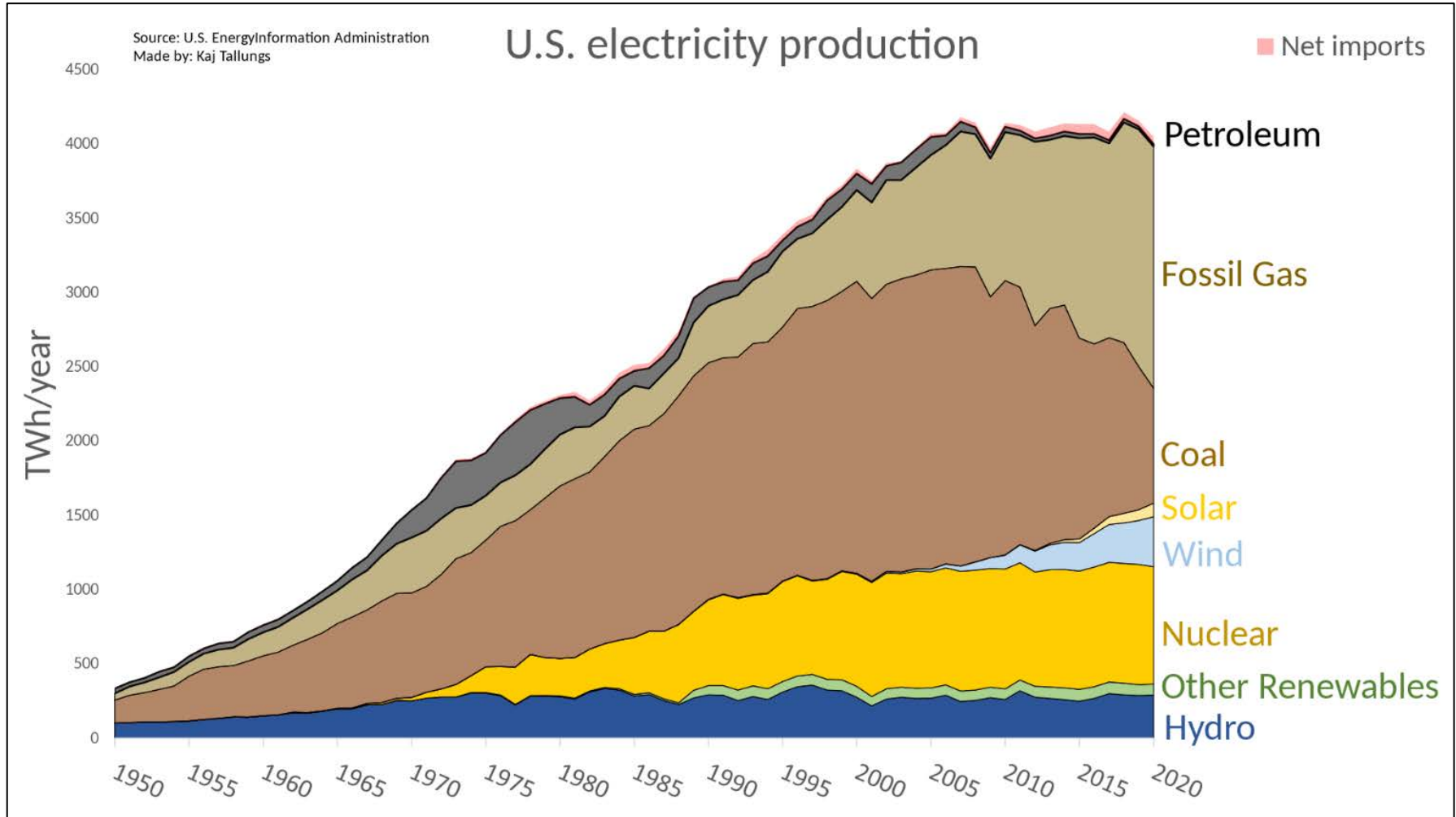
TODAY: CONVENTIONAL FUEL
– challenges of operating gas-fired SCR_s in a new generation environment



TOMORROW: HYDROGEN FUEL – important implications for operating SCR_s in future “green” landscape



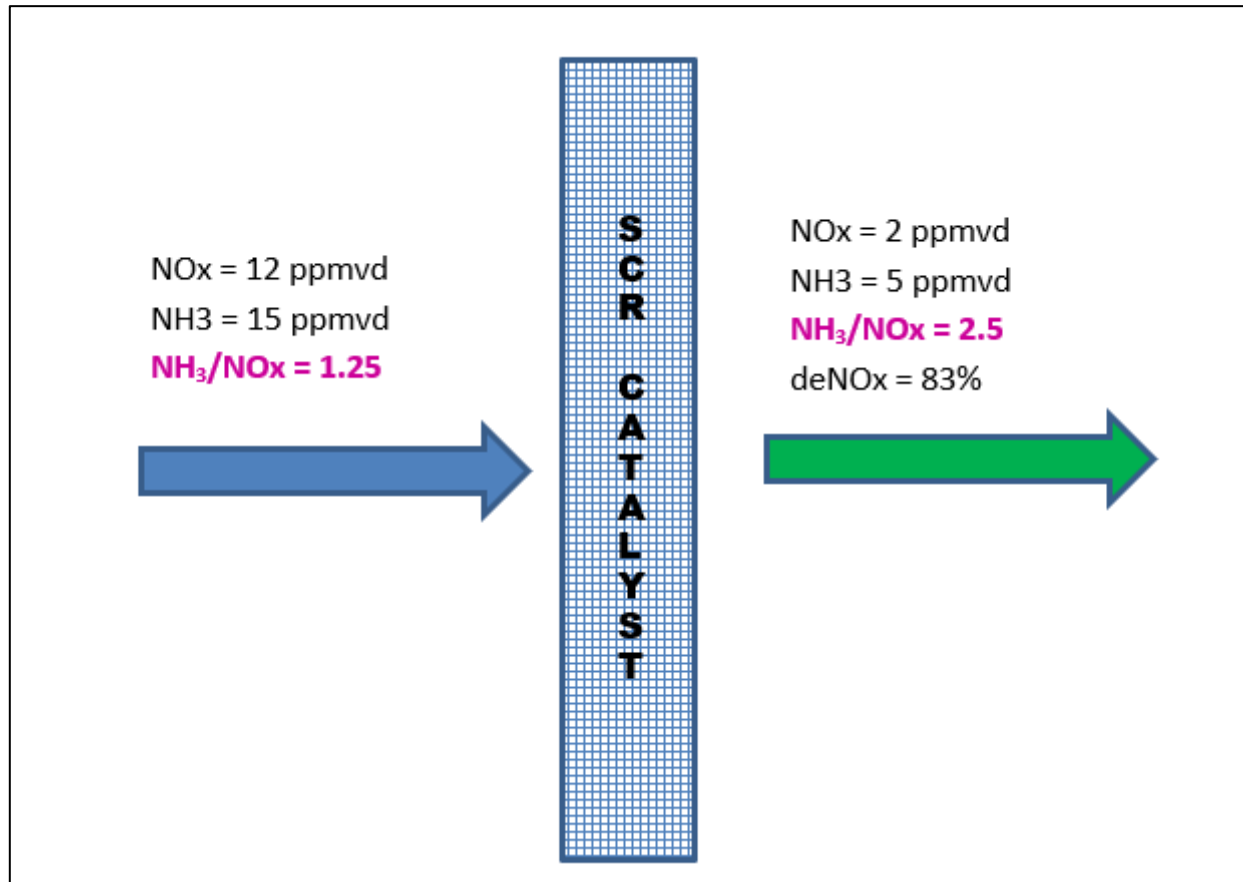
TODAY'S REALITY – GENERATION MIX



“BIG PICTURE” Operating Characteristics of CC SCRs

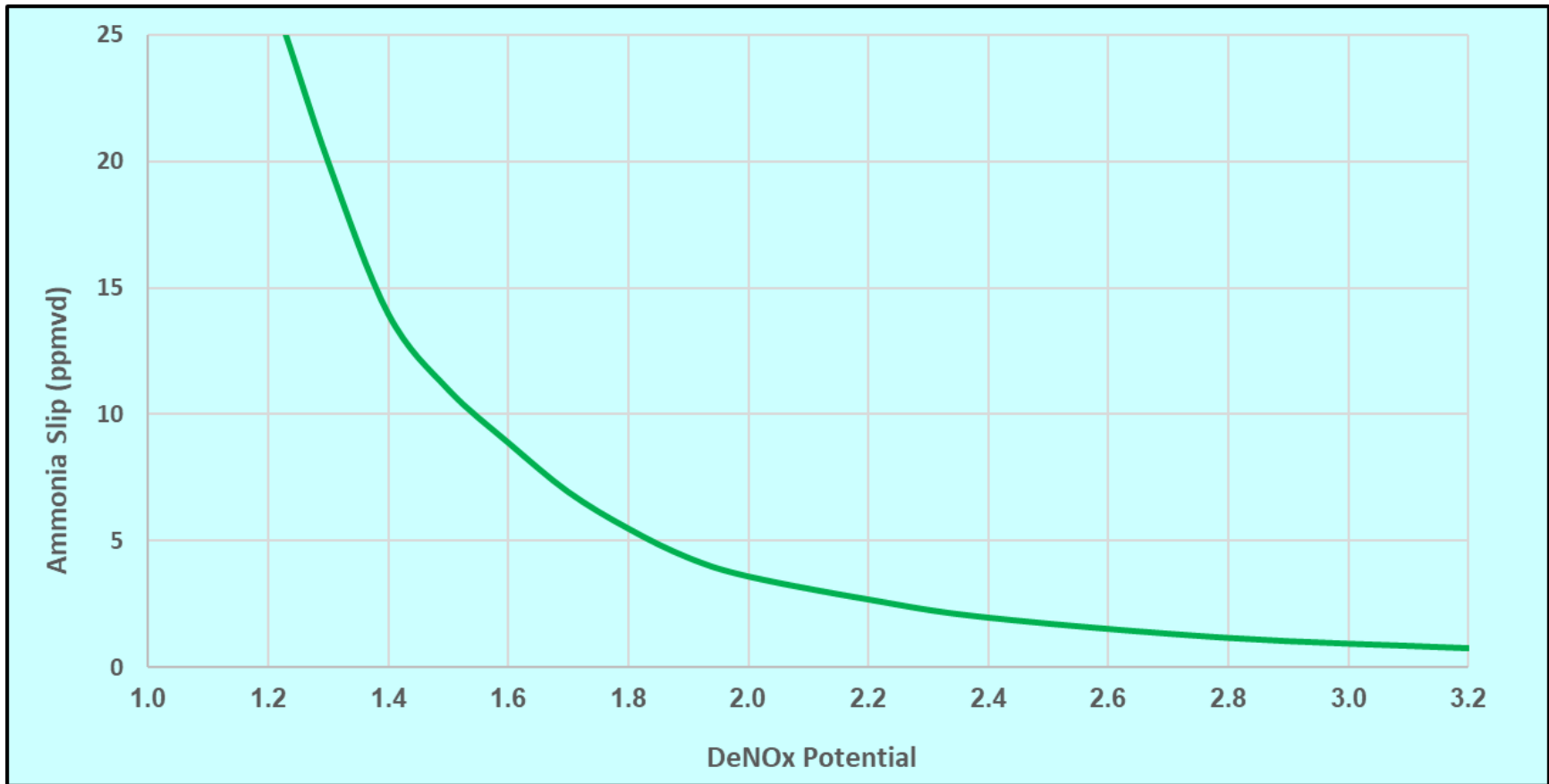
VERY HIGH LEVEL OF AMMONIA COMPARED TO NO_x

EXAMPLE END-OF-LIFE CONCENTRATIONS



“BIG PICTURE” Operating Characteristics of CC SCR

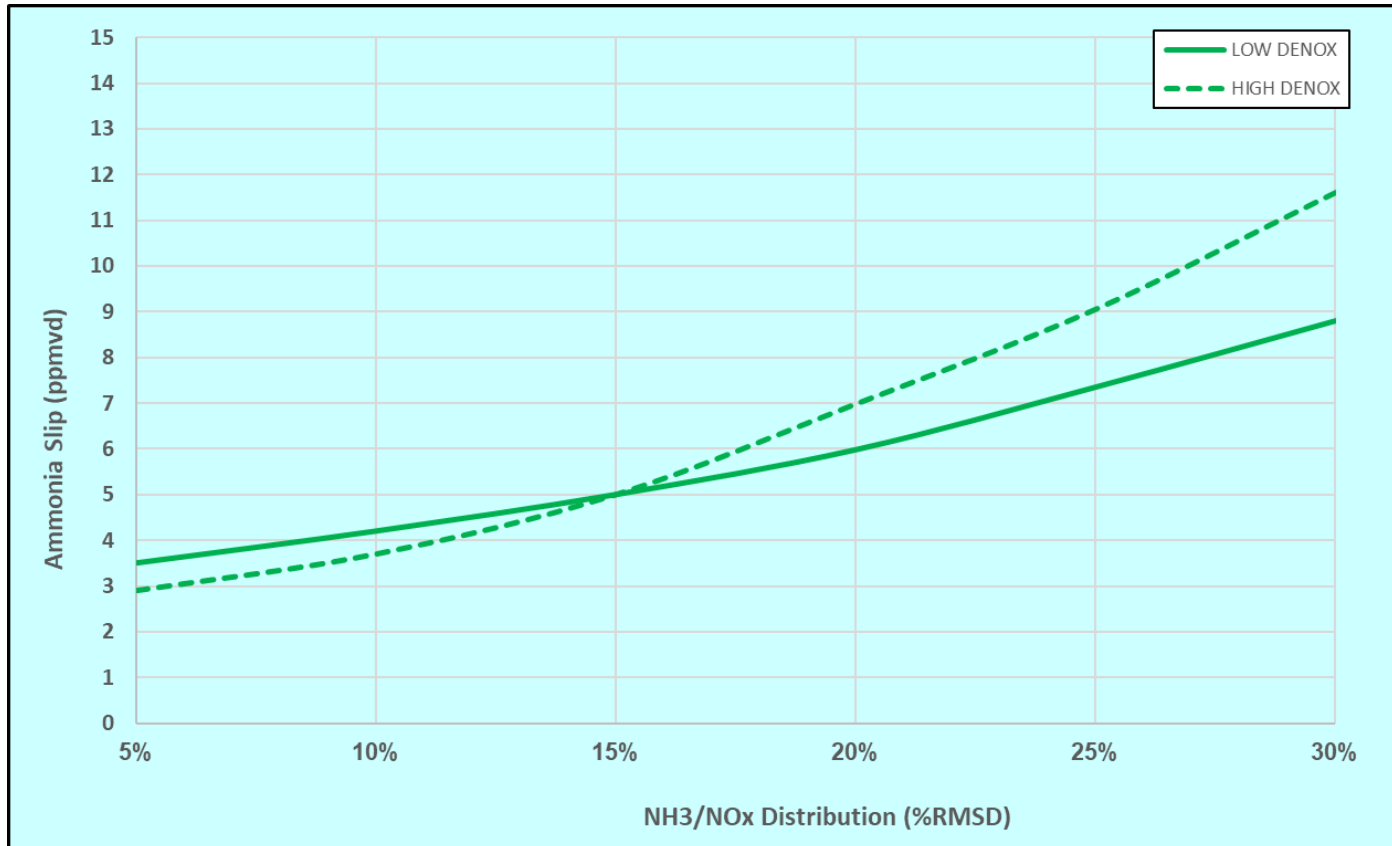
HIGH SENSITIVITY OF SLIP TO DeNO_x POTENTIAL NEAR END-OF-LIFE



Assumptions/Constants		
Inlet NO _x	12	ppmvd
Outlet NO _x	2	ppmvd
DeNO _x	83.3%	

“BIG PICTURE” Operating Characteristics of CC SCRs

SENSITIVITY OF SLIP TO NH₃/NO_x DISTRIBUTION



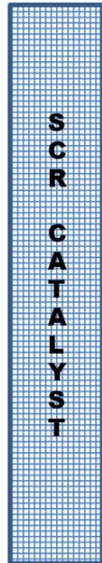
LOW DENOX		
Assumptions/Constants		
Inlet NO _x	12	ppmvd
Outlet NO _x	2	ppmvd
DeNO _x	83.3%	
P _{min}	1.84	
Design Slip	5	ppmvd
Design NH ₃ /NO _x Dist.	15%	RMSD

HIGH DENOX		
Assumptions/Constants		
Inlet NO _x	15	ppmvd
Outlet NO _x	1.5	ppmvd
DeNO _x	90.0%	
P	2.43	
Design Slip	5	ppmvd
Design NH ₃ /NO _x Dist.	15%	RMSD

CC Units Not Immune to SCR Problems: LEAK-BY

No Leak-By

NO_x = 12 ppmvd
NH₃ = 15 ppmvd
NH₃/NO_x = 1.25



NO_x = 2 ppmvd
NH₃ = 5 ppmvd
deNO_x = 83%

10% Leak-By

Catalyst much work much harder to compensate for leaked FG

Leaked Flue Gas
NO_x = 12 ppmvd
NH₃ = 15 ppmvd

Inlet Flue Gas
NO_x = 12 ppmvd
NH₃ = 15 ppmvd
NH₃/NO_x = 1.25

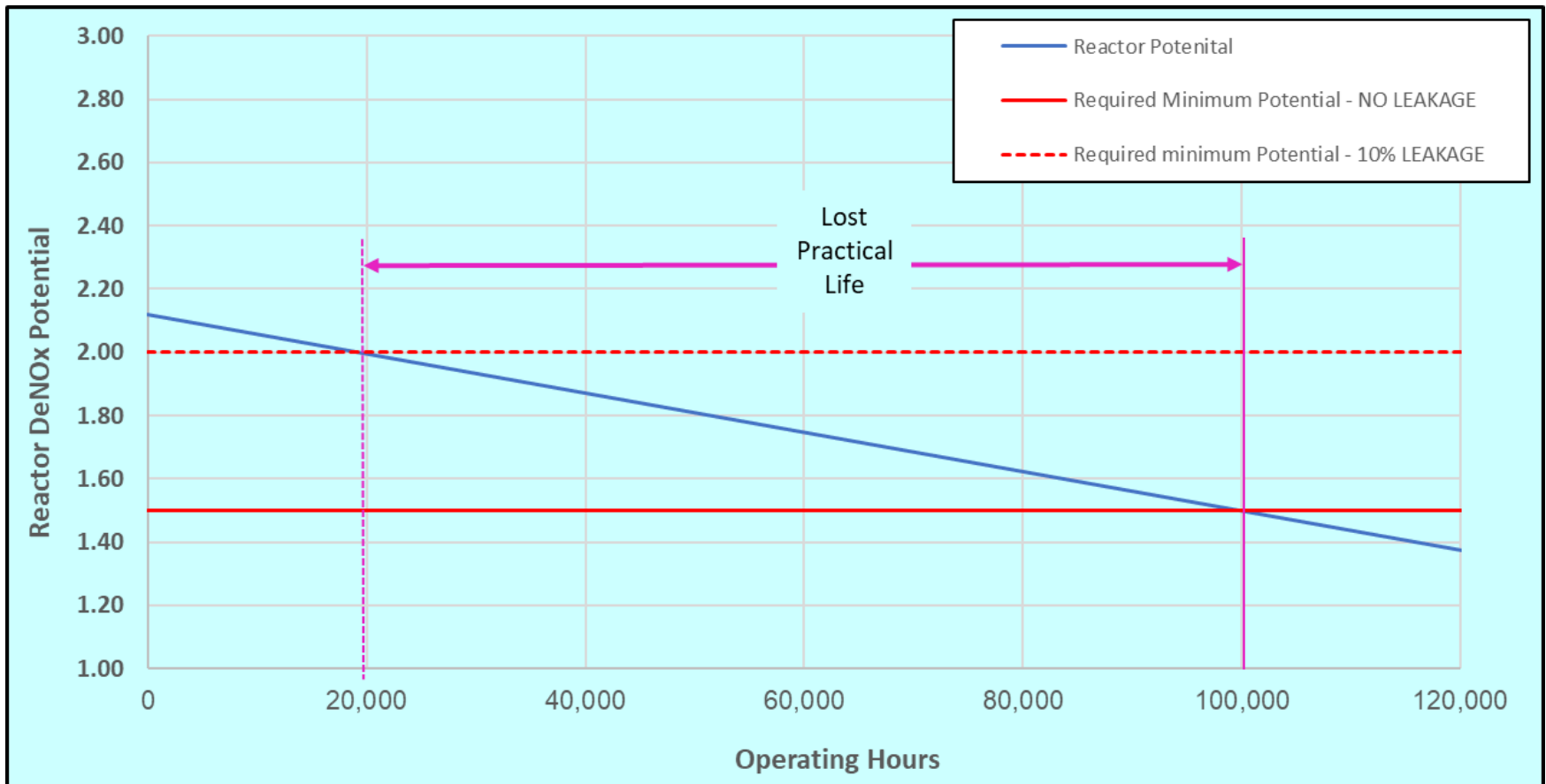


Processed Flue Gas
NO_x = .9 ppmvd
NH₃ = 3.9 ppmvd
deNO_x = 92.5%

Average Outlet
NO_x = 2 ppmvd
NH₃ = 5 ppmvd
deNO_x = 83%

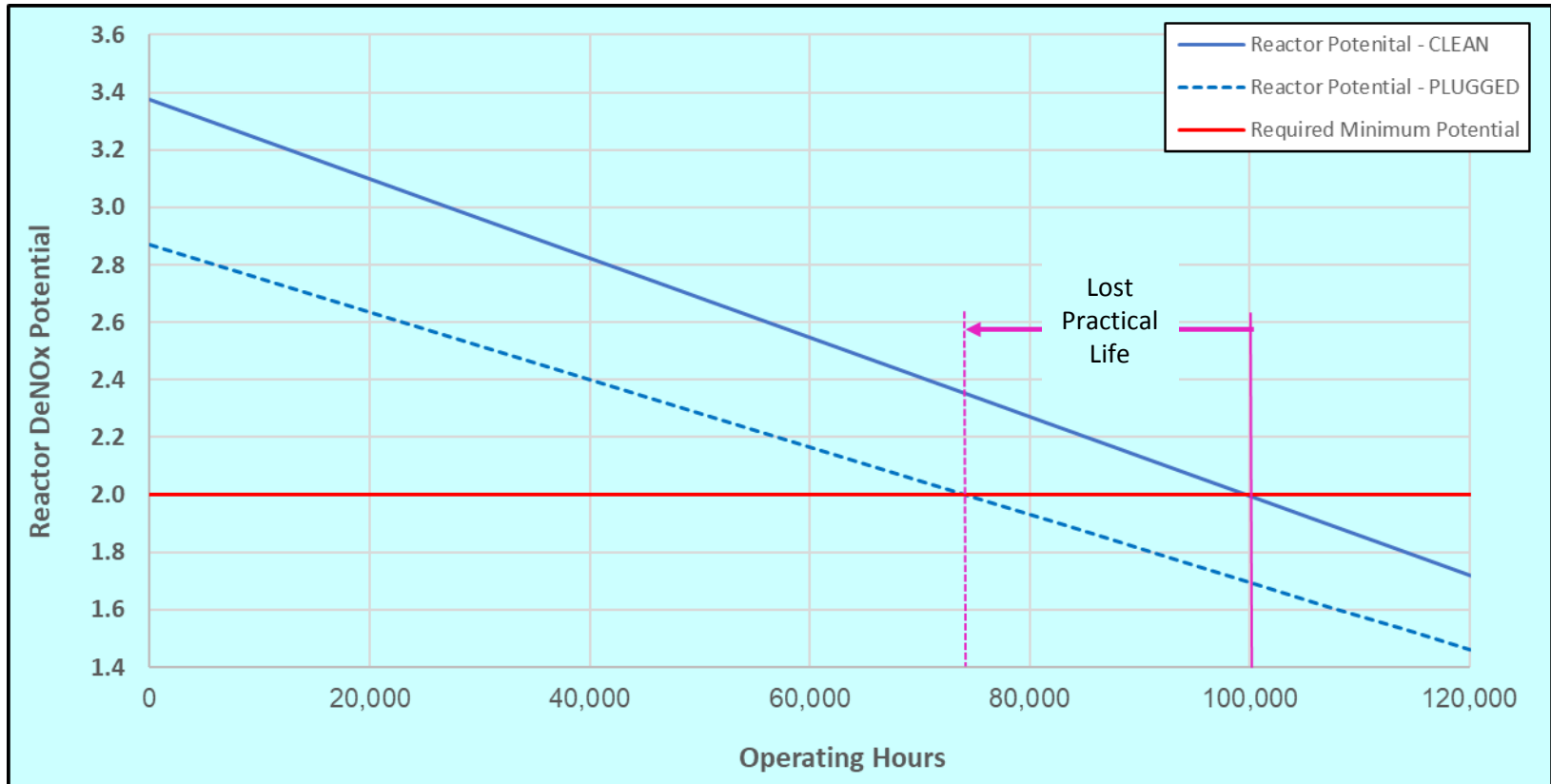
Leak-By Life Effect

Life effect using previous slide assumptions (maintain 83% deNO_x), 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.

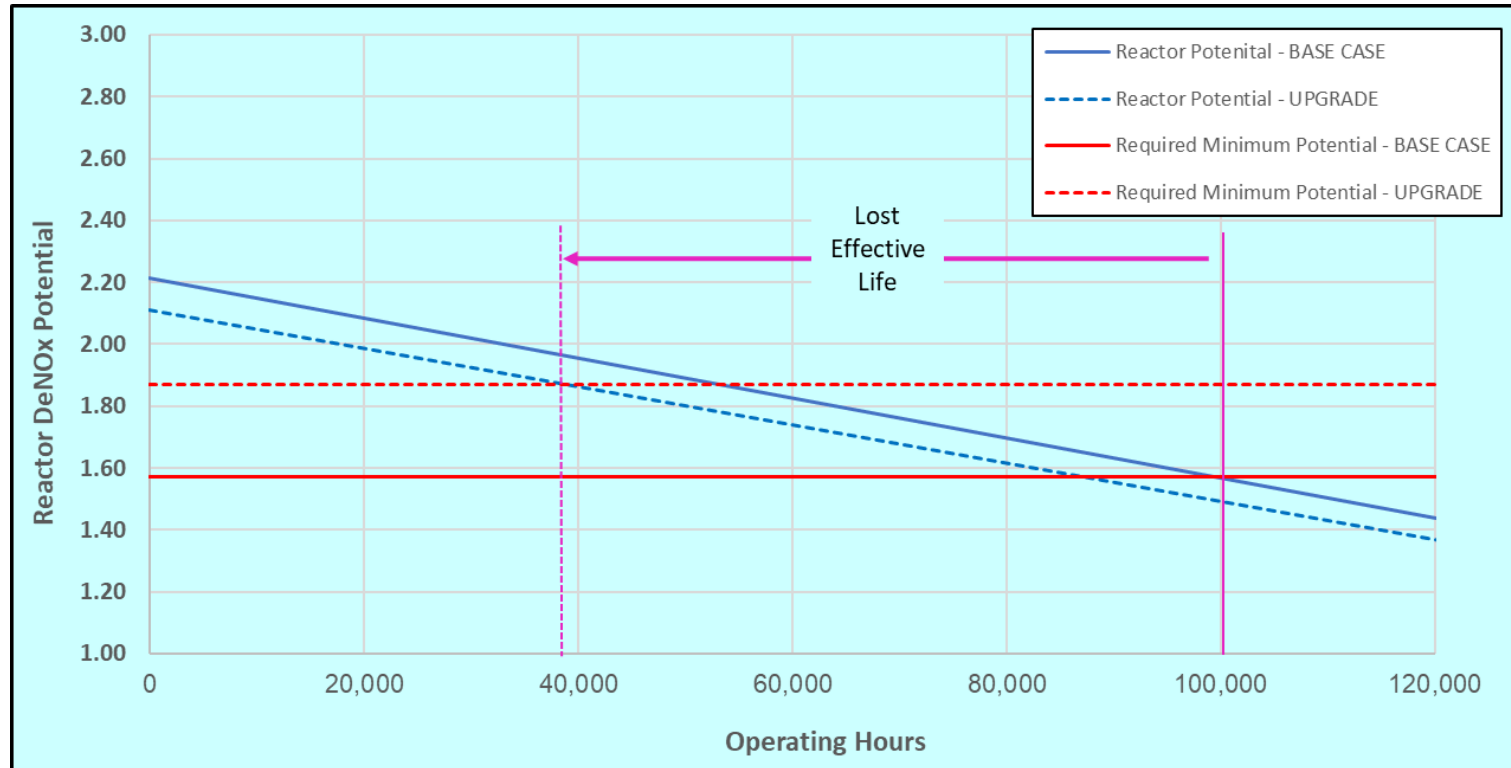


Assumptions		
CT NOx Production	0.05	lb/MMBtu
Inlet NOx	13.81	ppmvd at 15% O2
Outlet NOx	2	ppmvd at 15% O2
DeNOx	85.5%	
Slip	5	ppmvd at 15% O2
Pmin	2.0	
Plugging Level	15%	

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

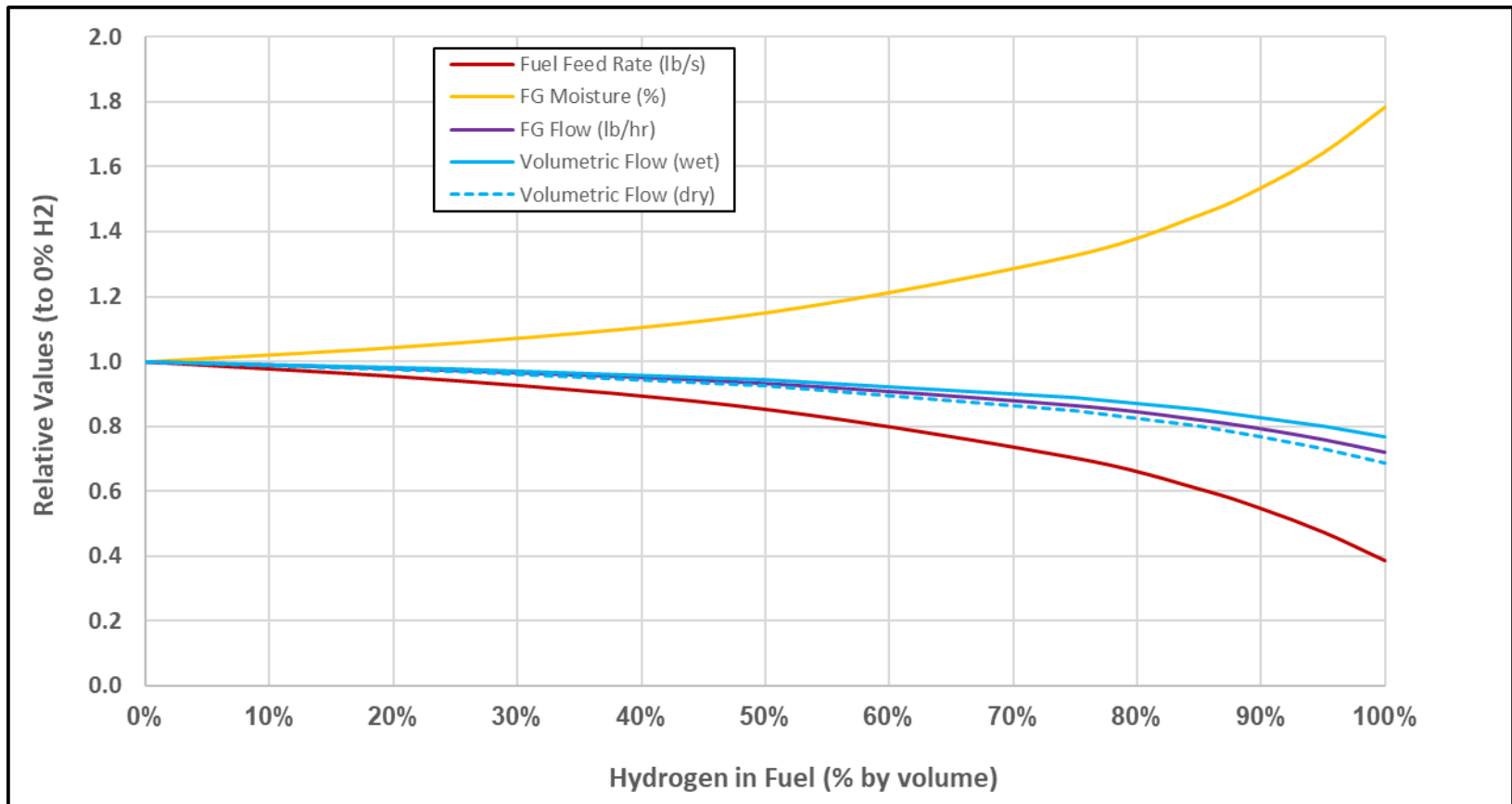
How will SCR and CO catalysts/systems be affected?

- Will change in flue gas constituents affect activity? (moisture, excess O₂, etc.)
- How will potential changes in NO/NO₂ affect deNO_x?
- Will current permits/regulations change?

HYDROGEN BLENDING EFFECTS ON FLUE GAS PRIMARY PARAMETERS

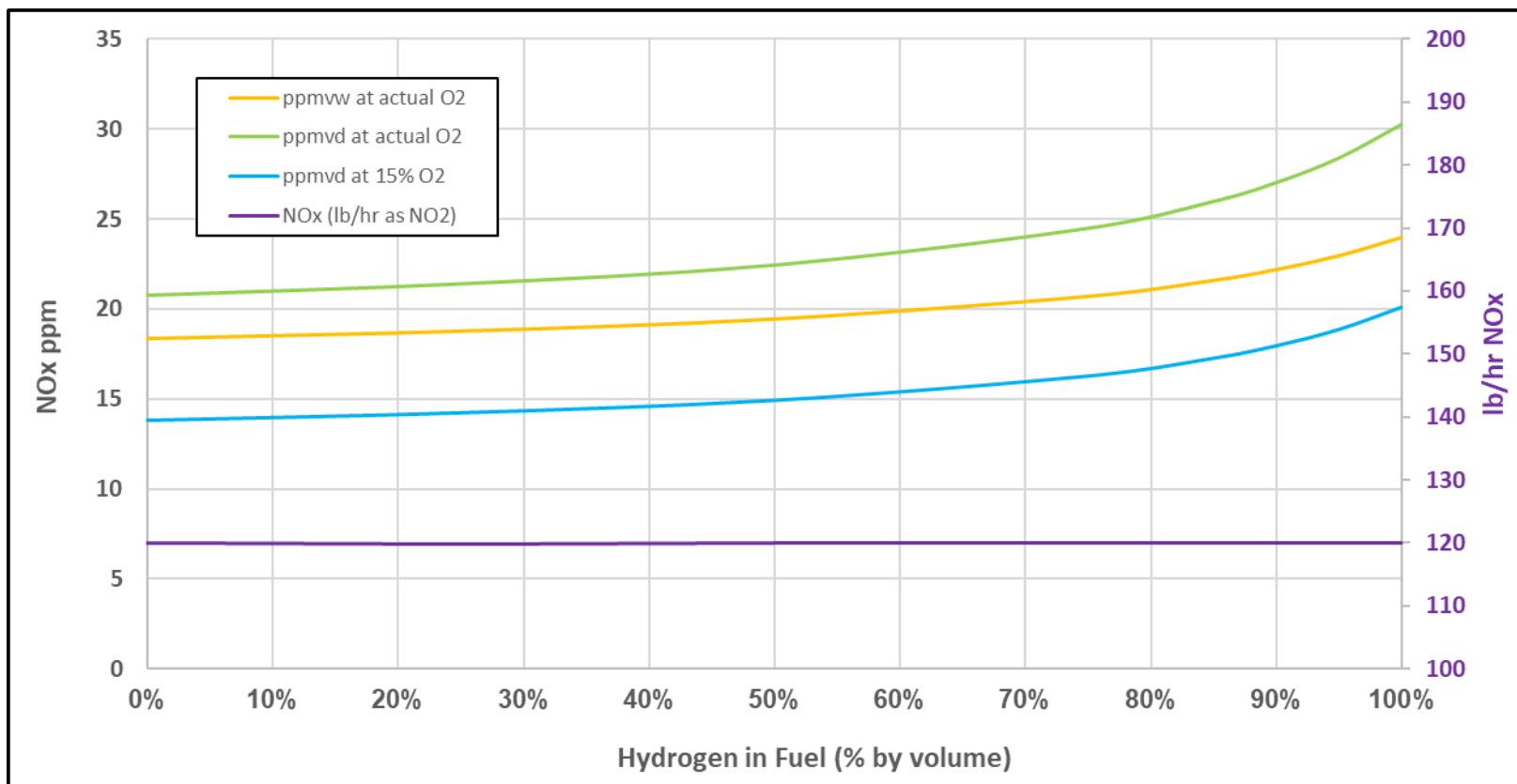
Assume excess O₂ (12%), and heat input are constant regardless of H₂ bend ratio.

These may or may not be good assumptions!



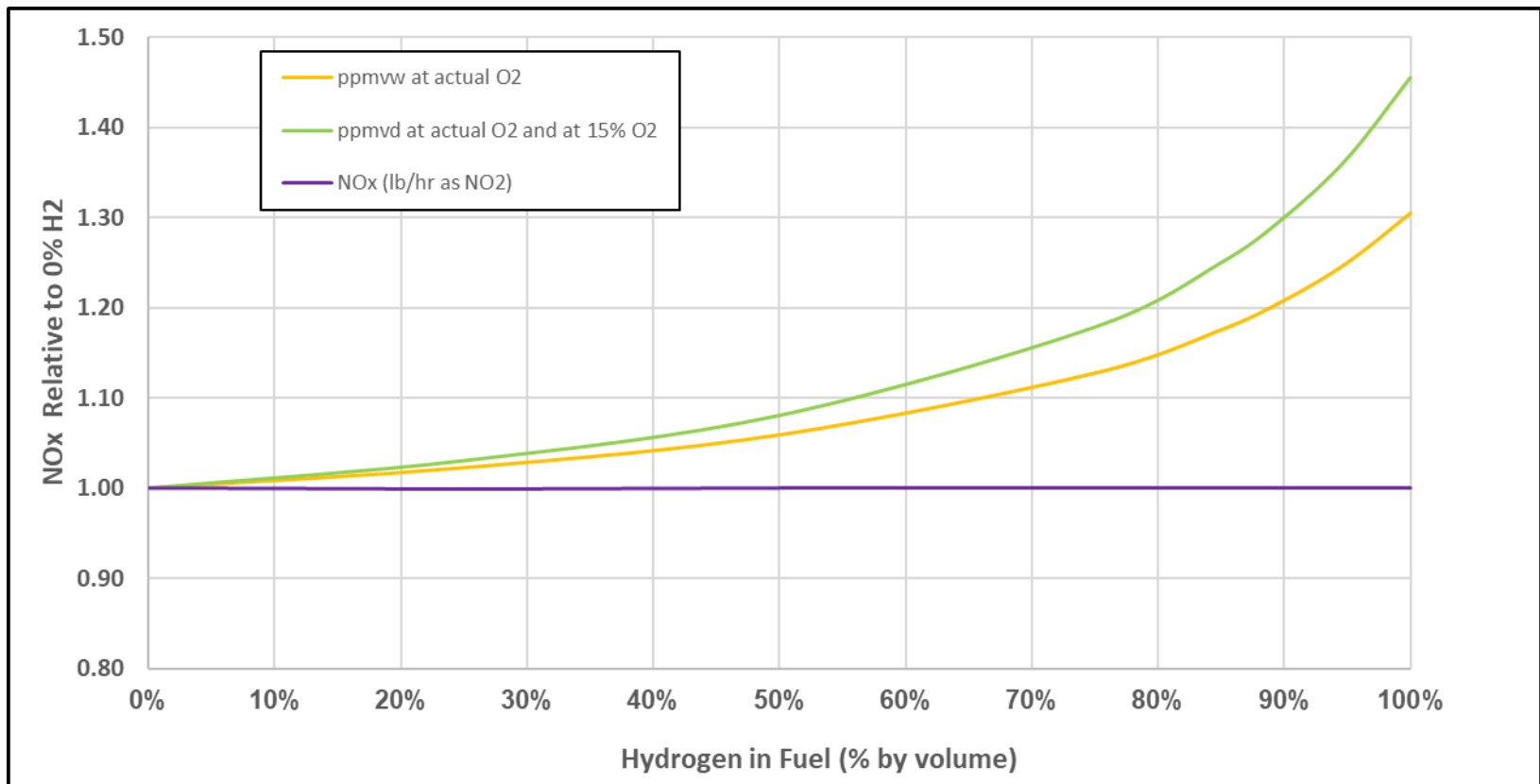
HYDROGEN BLENDING EFFECTS ON FLUE GAS NO_x CONCENTRATIONS

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



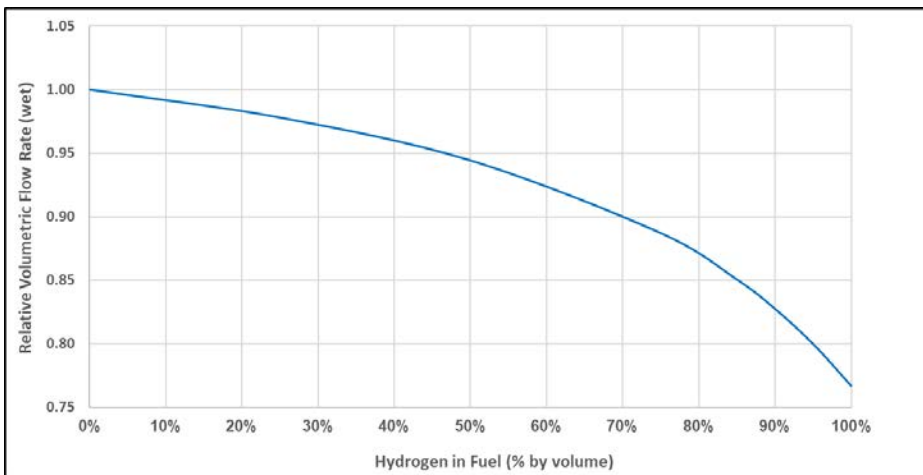
HYDROGEN BLENDING EFFECTS ON FLUE GAS RELATIVE NOx CONCENTRATIONS

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

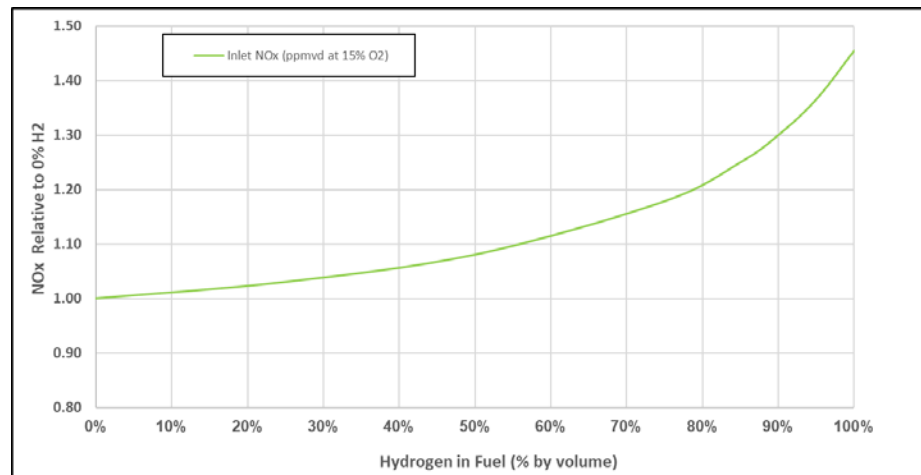


EXAMPLE HYDROGEN EFFECT ON SCR MARGIN: **Two offsetting effects**

Decreased volumetric flow raises **actual** reactor deNOx potential
($P=K/AV$, Flow ↓, AV ↓, P ↑)

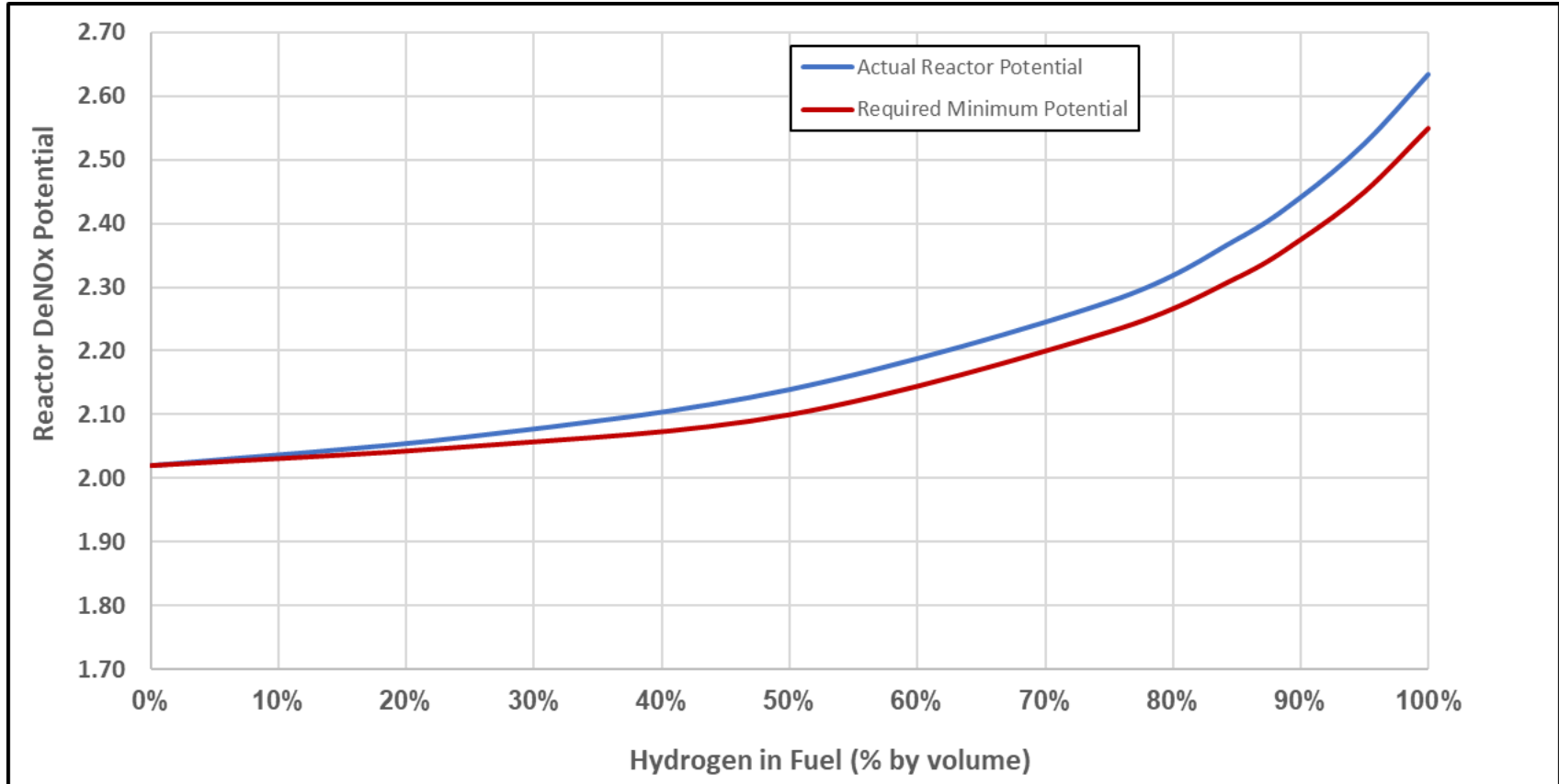


Increased SCR inlet NOx raises **minimum** deNOx potential when holding slip constant on ppmvd at 15% O₂ basis.



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



umicore
Catalysis

Impact of H₂ in Gas Turbines on SCR Systems

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A&WMA West Coast Section - October 2021
Brian Helner CORMETECH Inc.

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