COMPRESSOR TECH² HYDROGEN SUMMIT

HOUSTON, TX

APRIL 25, 2023

Jacob Saletsky

COMPRESSOR TECH²

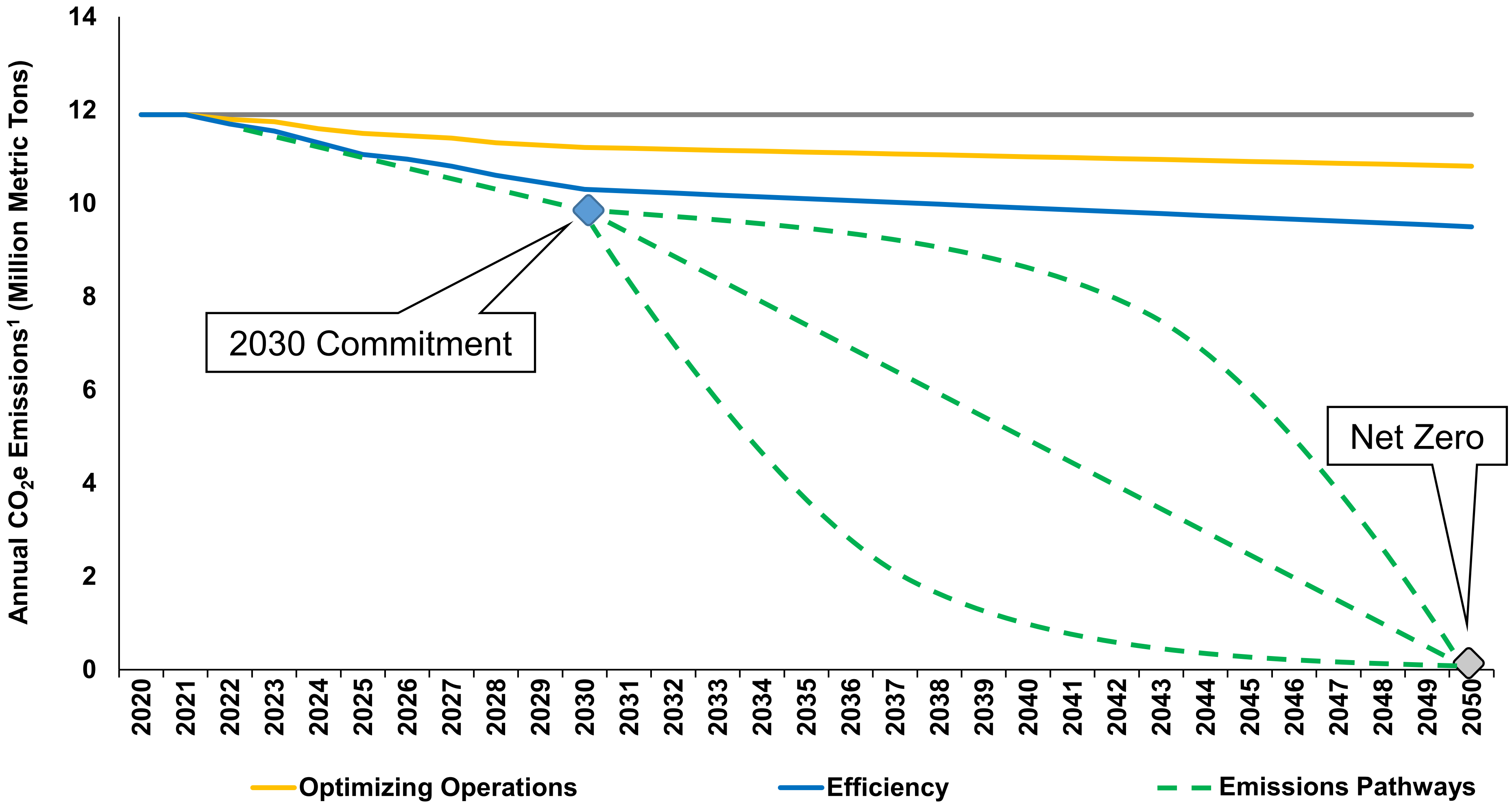
DEDICATED TO GLOBAL GAS COMPRESSION PRODUCTS AND APPLICATIONS

POWERED BY khl

AGENDA

- Overview – New Energy Ventures
- Why Hydrogen?
- Fuel Gas Blending Test – Kemmerer CS
- Potential Fuel Gas Blending Projects
- Additional Considerations Around Compression

NEW ENERGY VENTURES



Achieve
carbon reductions for ourselves, our customers and partners

Create
economic value with actionable investments

Target
opportunities where our midstream competencies provide strong competitive advantages

Provide
scalable options for the future

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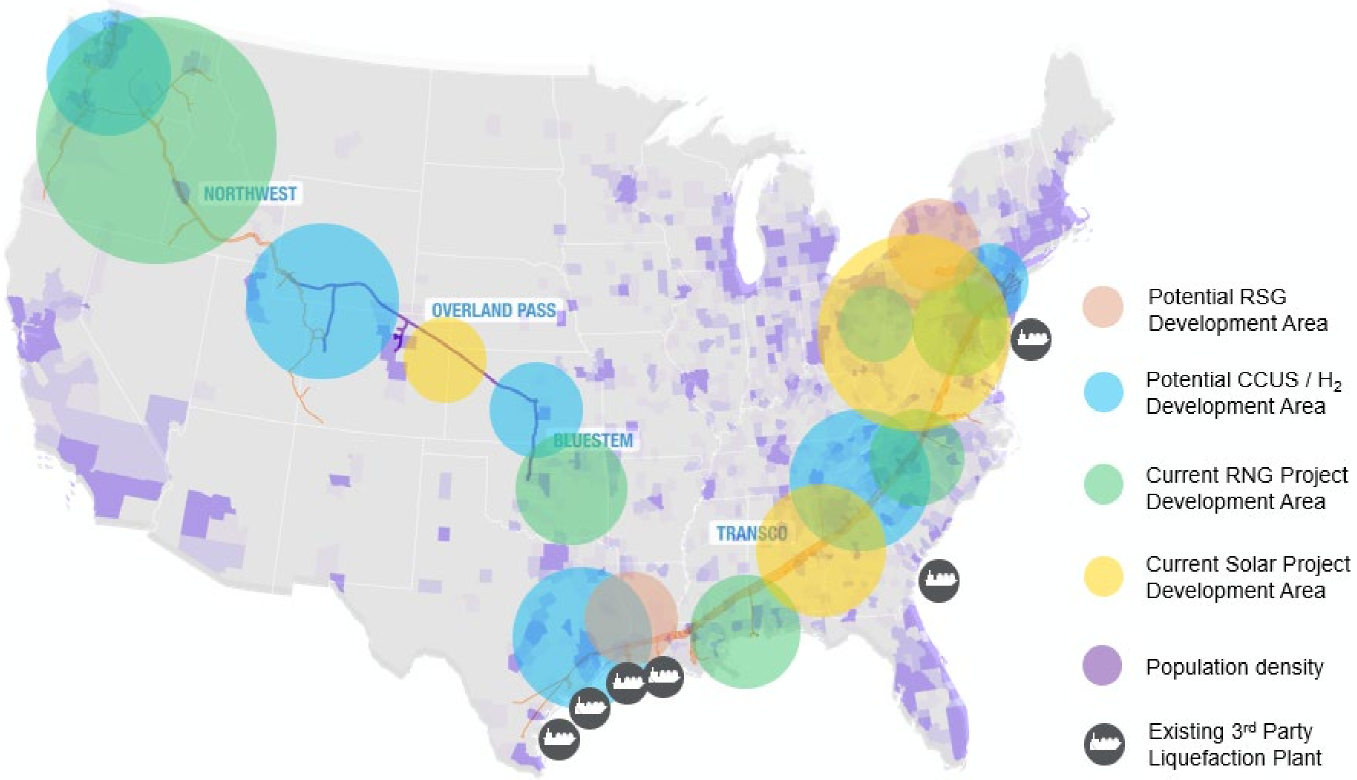
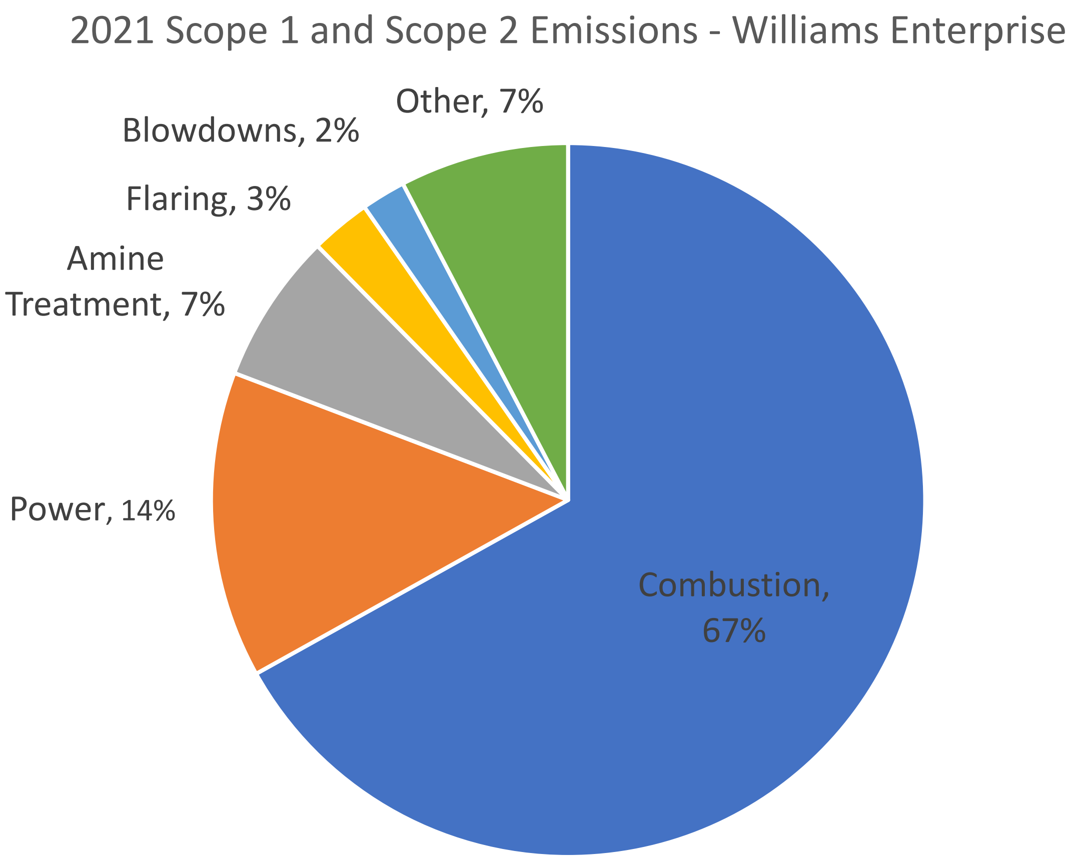
WHY HYDROGEN?





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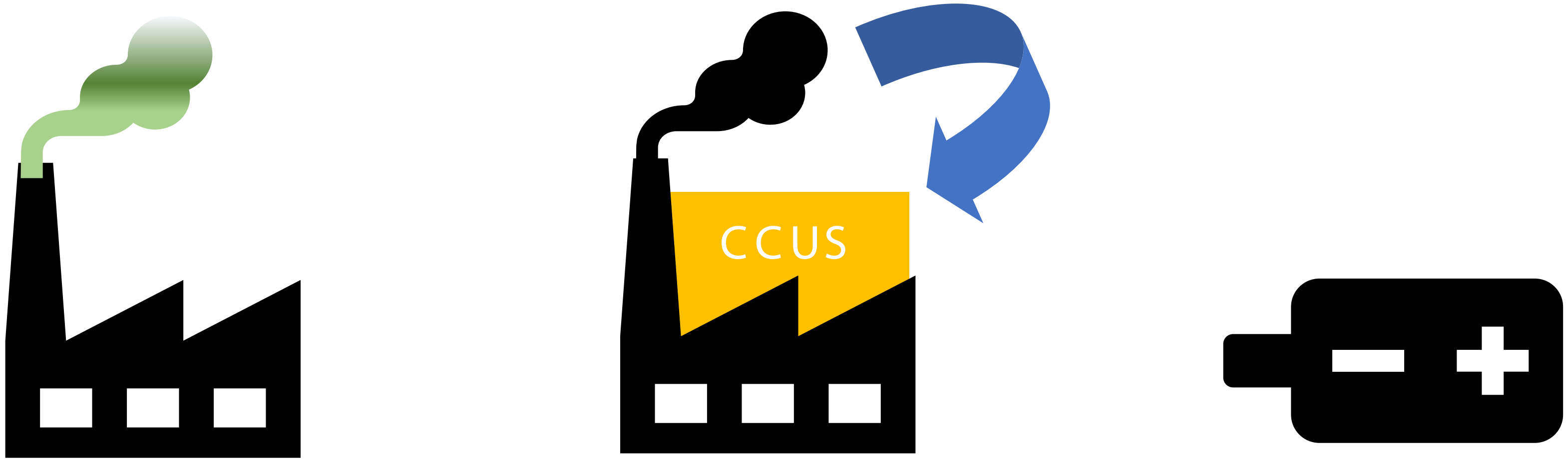
WHY HYDROGEN?



	Hydrogen Based Fuels	Post-Combustion Carbon Capture	Electric Drive
Reliability Preserved?	Yes	Yes	No
Small-Scale Implementation?	Yes	No	Yes
Incremental Installation?	Yes	No	No

PROJECT MOTIVATION

Williams Awarded Grant for Hydrogen Research in Wyoming

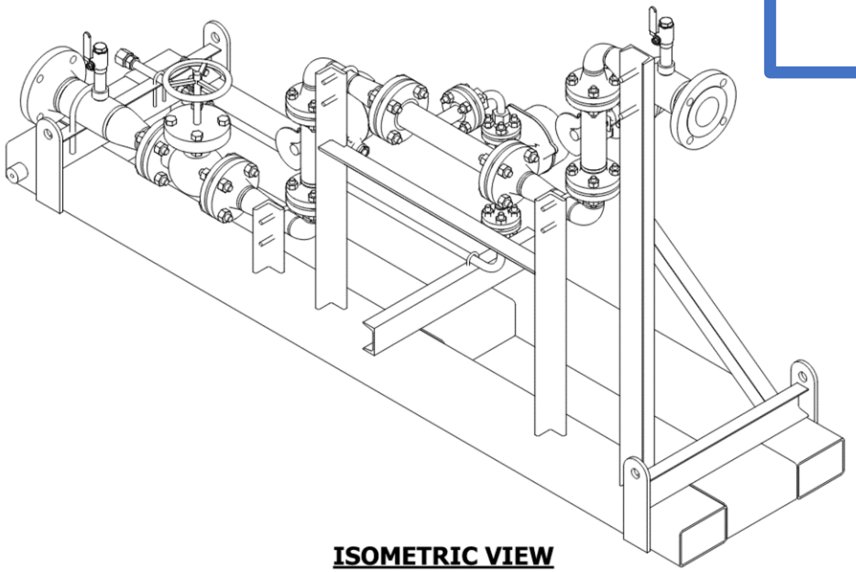
STAFF REPORTS

Williams has received a grant for nearly $1 million from the Wyoming Energy Authority (WEA) to complete a feasibility study to evaluate water access, compatibility and asset integrity in support of green hydrogen production and transport in the vicinity of Wamsutter and Opal, Wyoming. In addition, Williams will provide $200,000 as a match to the funds received making the total value of the grant $1,197,734.

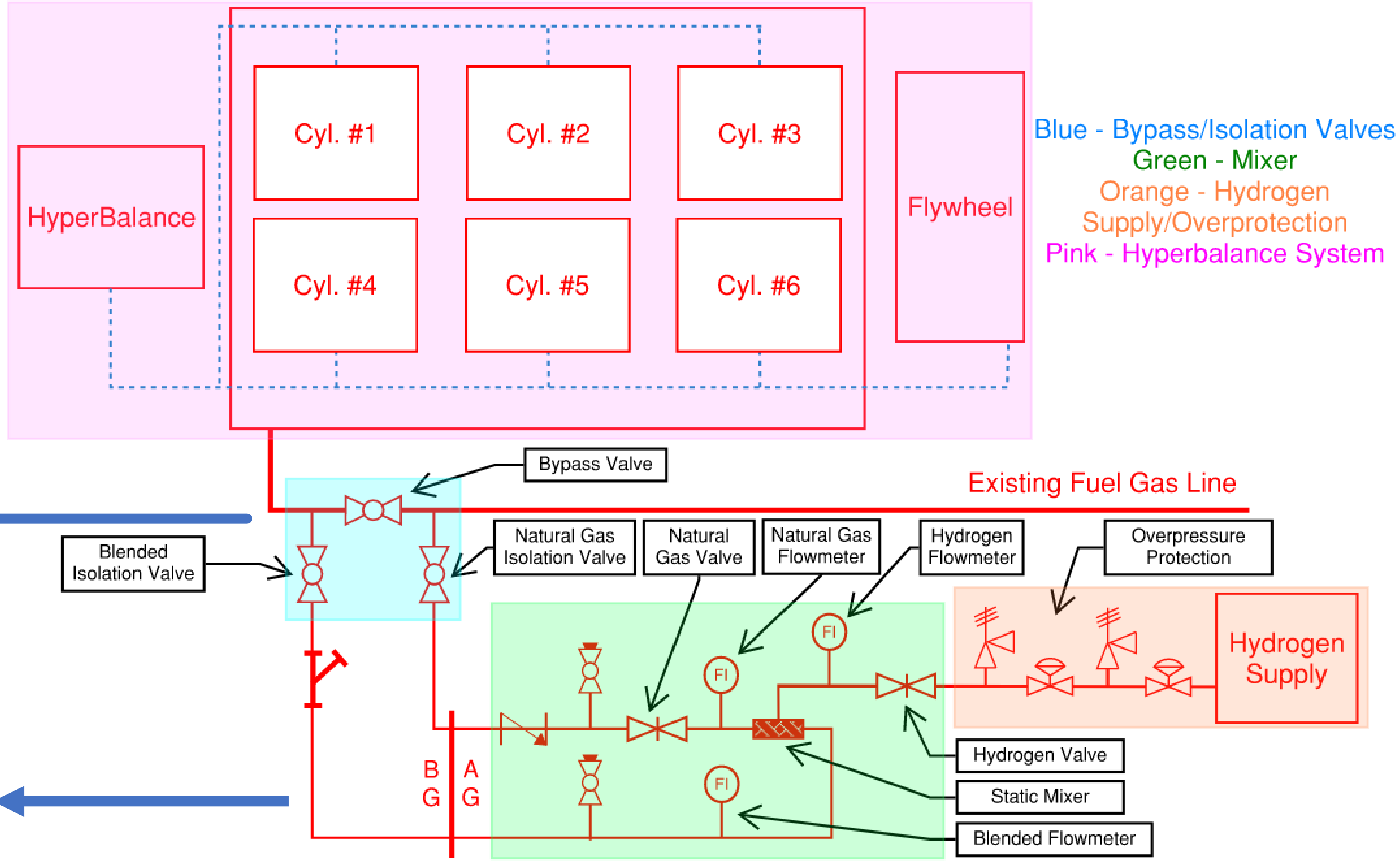
"The results of this study could enable future development of green hydrogen production and/or synthetic natural gas production in southwest Wyoming," said William De Los Santos, business development lead, Corporate Strategic Development. "There is potential for us to support the state's objective of creatinga clean energy hub – utilizing renewable power production, green hydrogen production, carbon capture and hydrogen or synthetic natural gas transportation."

If this sounds like a exciting project that supports our ESG goals, you're right. The study has an 18-month schedule, with completion in January 2023.

PROJECT DESIGN



ISOMETRIC VIEW



MAJOR COMPONENTS

Mixer

FTIR

HyperBalance

Hydrogen Supply and OPP

ASME B31.8 vs ASME B31.12

PL-1.1 SCOPE

Rules for this Part of the Code apply to transmission pipelines, distribution pipelines, and service lines used for transporting hydrogen from a production facility to the point of final use.

PL-1.2 CONTENT AND COVERAGE

This Part sets forth requirements for materials, components, design, fabrication, assembly, erection, inspection, examination, testing, operation, and maintenance of hydrogen pipelines.

PL-1.3 EXCLUSIONS

This Part excludes the following:

(a) design and manufacture of pressure vessels covered by the ASME BPVC

(b) pipeline systems with temperatures above 232°C (450°F) or below −62°C (−80°F)

(c) pipeline systems with pressures above 21 MPa (3,000 psig)

(d) pipeline systems with a moisture content greater than 20 ppm [dew point at 1 atm = −55°C (−67°F)]

(e) pipeline systems with a hydrogen content less than 10% by volume

Option A - Prescriptive Method:

- In lieu of extensive testing, a pressure cut must be taken to the MAOP based upon pipe class and grade.
- For this case, **the pressure cut would be 50% of MAOP.**

Option B – Performance Method **(12 tests total):**

- To remove any pressure cut requirements, stress intensity curves must be developed for three distinct heats on a sample of the pipe body, HAZ, and welds themselves.
- In addition, a Charpy V-Notch hardness and tensile test must be completed on a sample of the pipe body, HAZ, and girth or longseam weld.

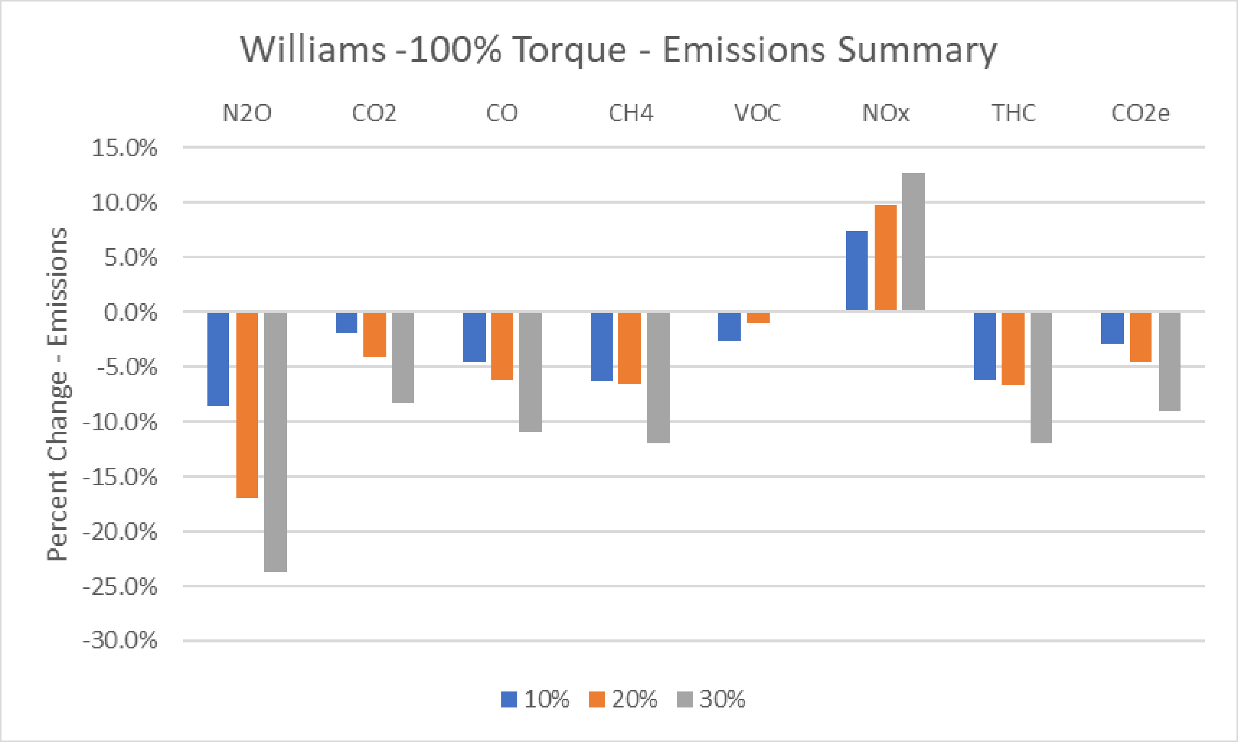
SAFETY PRECAUTIONS

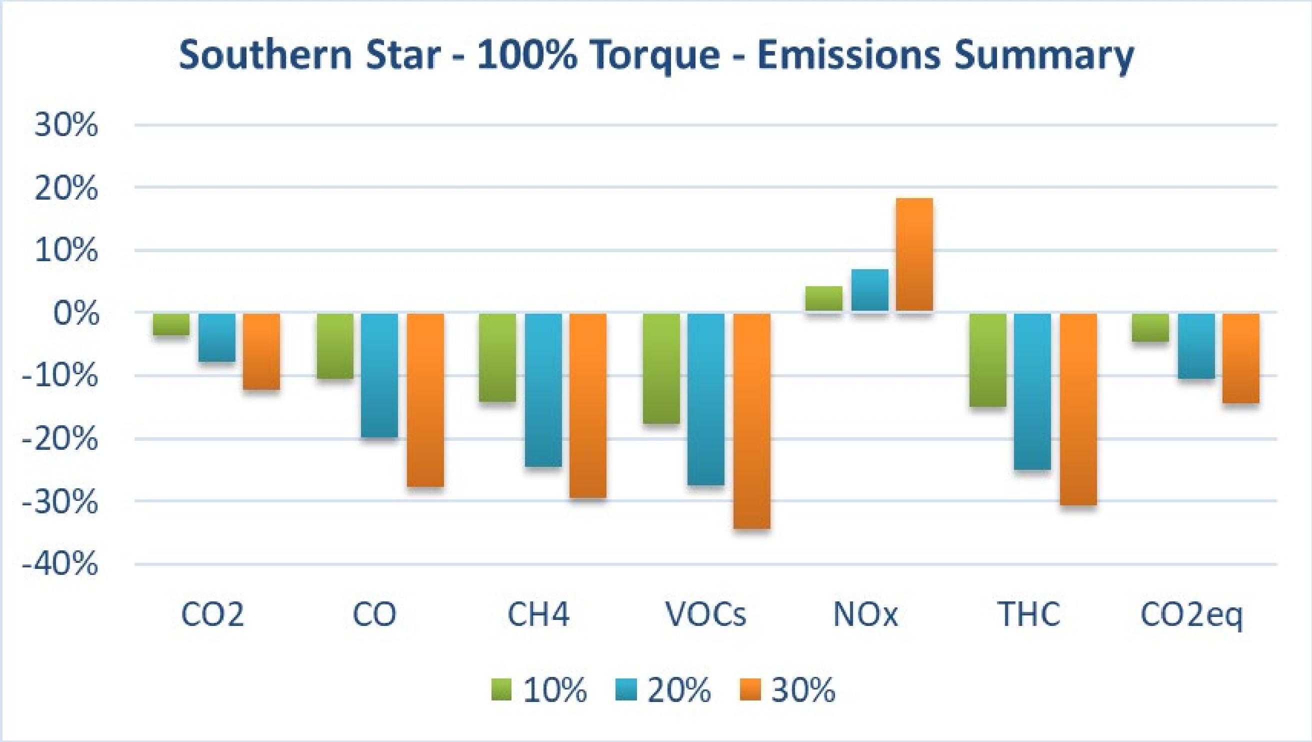
- Leak sweeps with portable hydrogen detectors and leak testing with Helium.
- Manned unit shutdown during increase/decrease in hydrogen concentration.
- Isolating unit from rest of the station at the conclusion of each day.
- Verification that presence of hydrogen did not violate station EAC.

TEST INTERVALS

Day	Runs	Approx. AMP (in Hg)	Approx. IT (°BTDC)	Approx. Engine Torque (%)	Approximate Hydrogen Concentration
9/9/2022 (Baseline)	Runs #2 - #4	11.5, 13, 13.5	8, 4, 4	100%	0%
	Runs #5 - #8	12	4, 6, 8, 10	100%	0%
9/10/2022 (5% Hydrogen)	Runs #9 - #11	10, 11, 12.5	6	100%	0%
	Runs #12 - #15	12, 12.5, 11, 10	6	100%	5%
	Runs #16 - #18	12	4, 8, 10	100%	5%
9/11/2022 (10% Hydrogen)	Runs #20 - #23	12, 12, 11, 10	6	100%	10%
	Runs #24 - #26	12	2, 4, 6	100%	10%
9/12/2022 (15% and 20% Hydrogen)	Runs #28 - #31	10, 11, 12	6	100%	15%
	Runs #32 - #34	12	2, 4, 6	100%	15%
	Runs #35 - #36	12	2, 4	100%	20%
	Runs #37 - #38	11.5, 10.5	6	100%	20%
9/13/2022 (Torque Sweep)	Runs #39 - #45	12, 11, 12, 12, 12, 12, 12	5	100%	0%, 5%, 10%, 15%, 20%, 25%, 30%
	Runs #46 - #49	11, 11, 10.5, 10.5	5	90%	0%, 10%, 20%, 30%
	Runs #50 - #54	10, 9, 8, 9, 9	5	80%	0%, 10%, 20%, 25%, 30%
	Runs #55 - #58	9, 8, 7.5, 7	5	70%	0%, 10%, 20%, 30%

RESULTS -100% ENGINE TORQUE





$$CO_{2e} = CO_2 + 25(CH_4) + 298(N_2O)$$

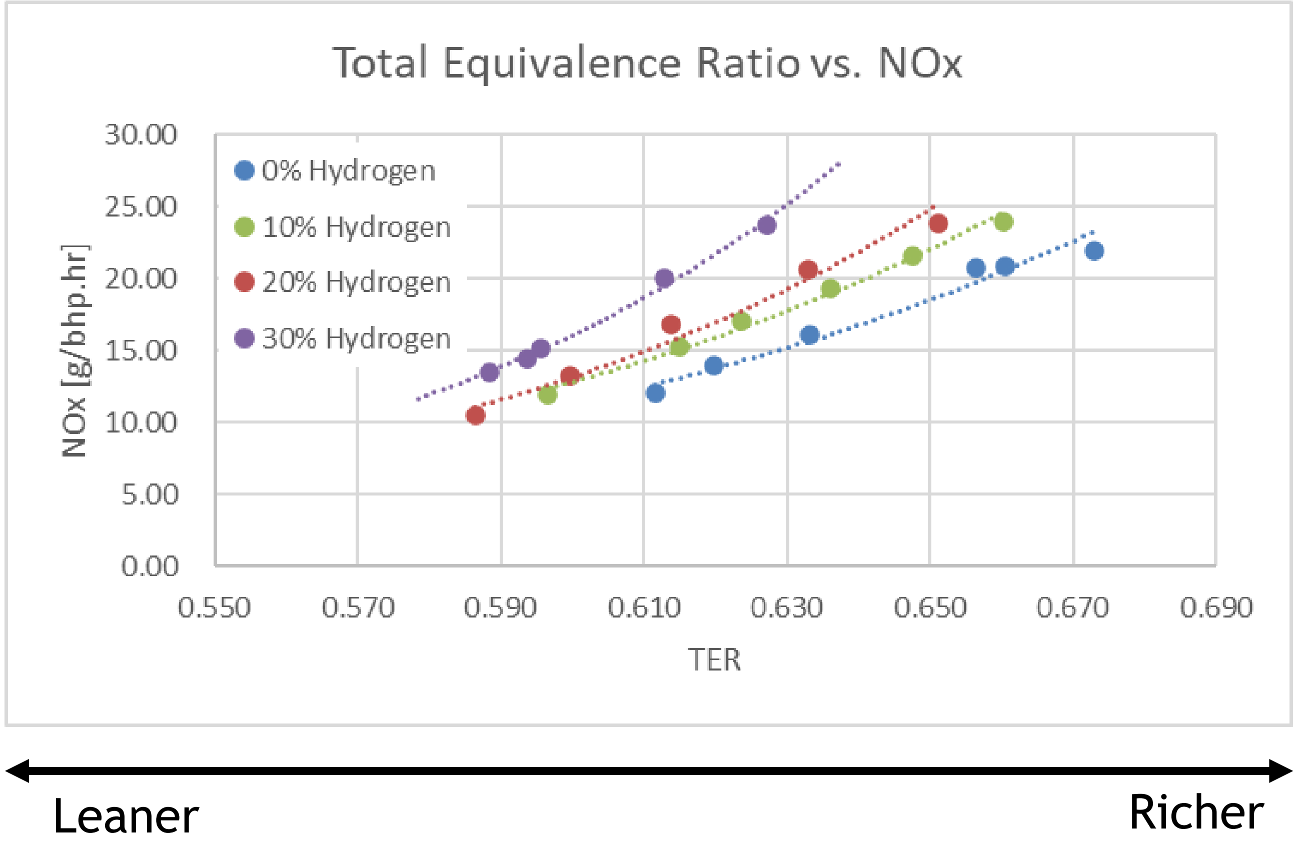
RESULTS - NOx

At what percentage hydrogen will NOx increase?

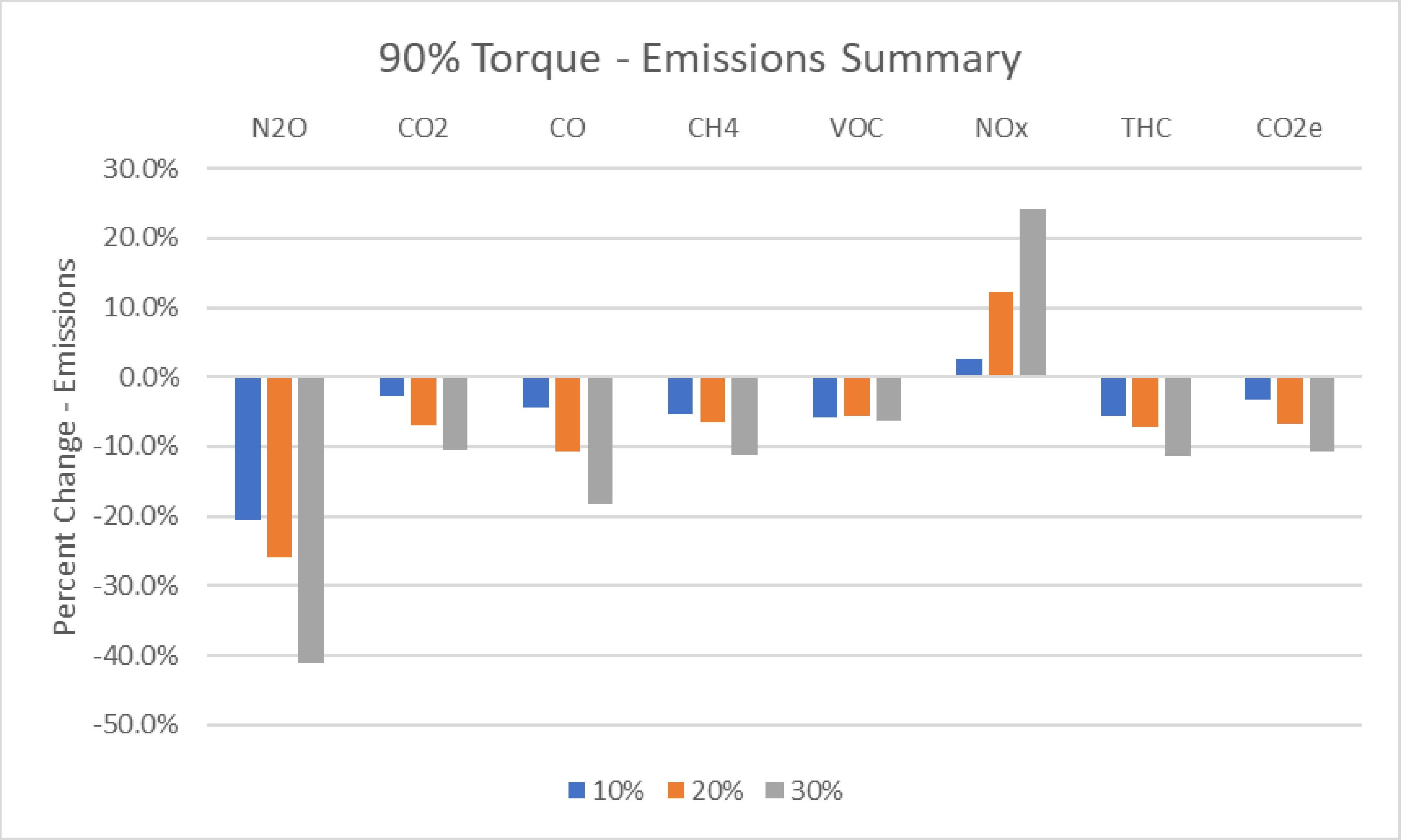
- Instantaneously!

How can you reduce NOx emissions while retaining reductions in other emissions?

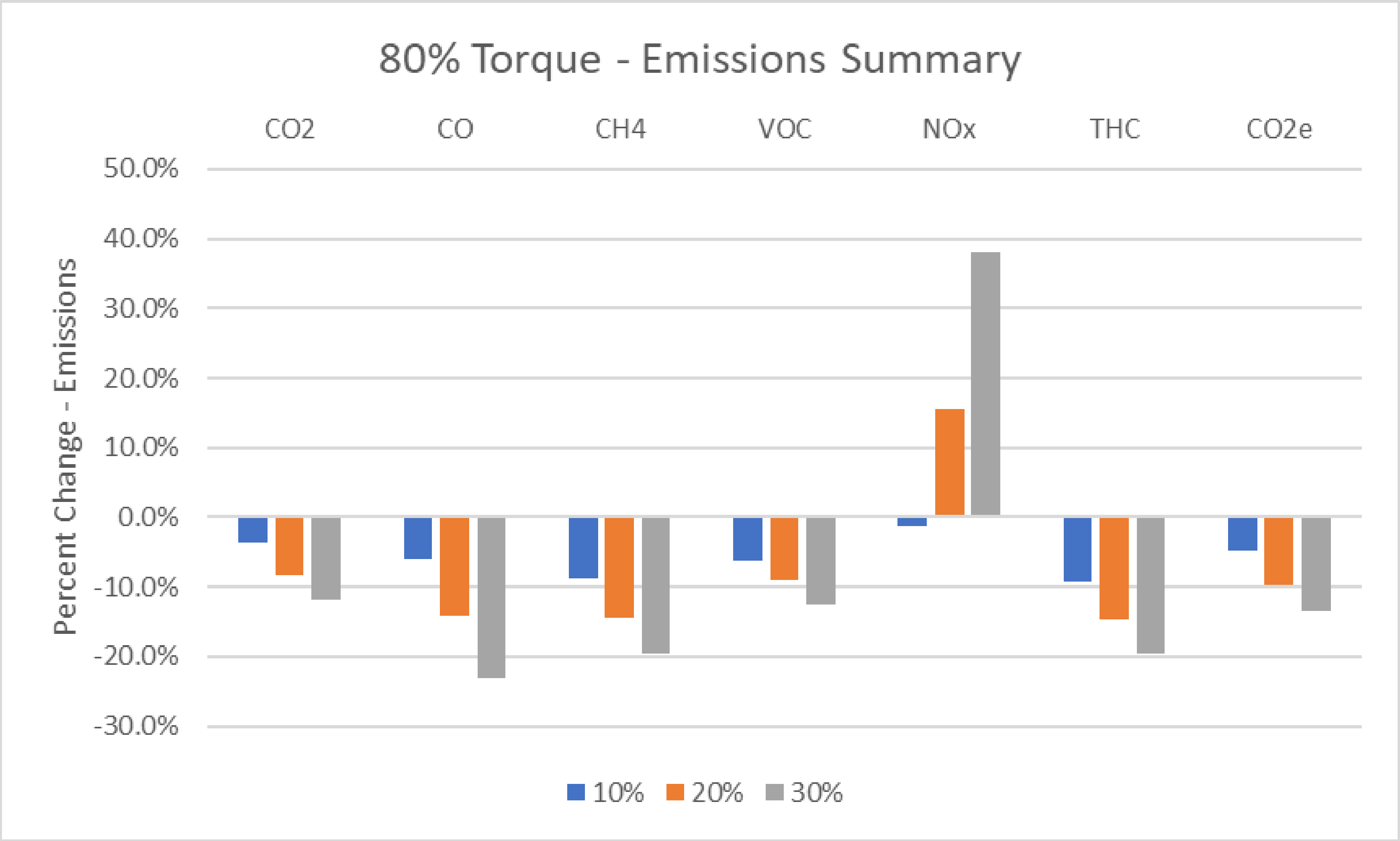
- Without upgrades, NOx can be reduced (with hydrogen!) by leaning out the fuel further, but only to a point.
- Upgrading the turbo and installing HPFI can result in greater airflows to the engine.



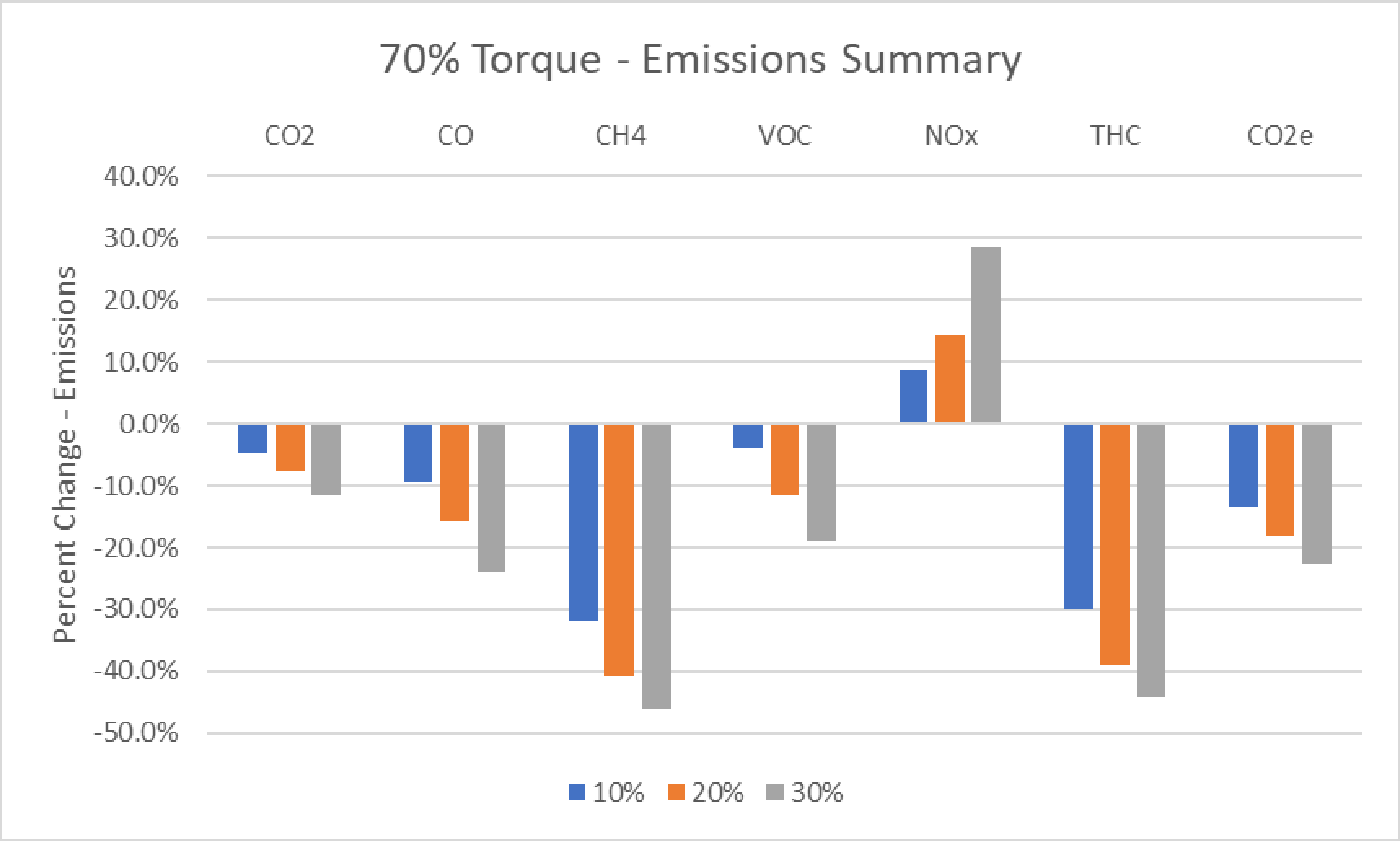
RESULTS – 90% ENGINE TORQUE



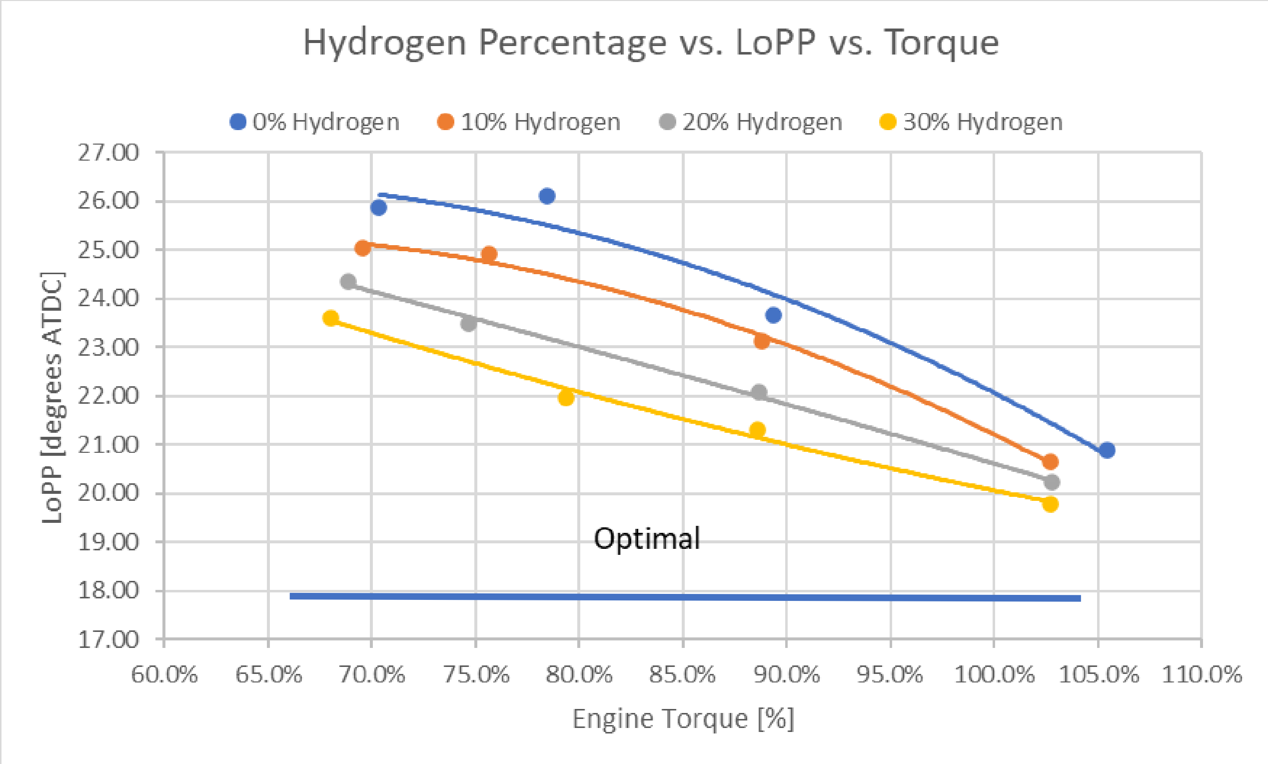
RESULTS – 80% ENGINE TORQUE

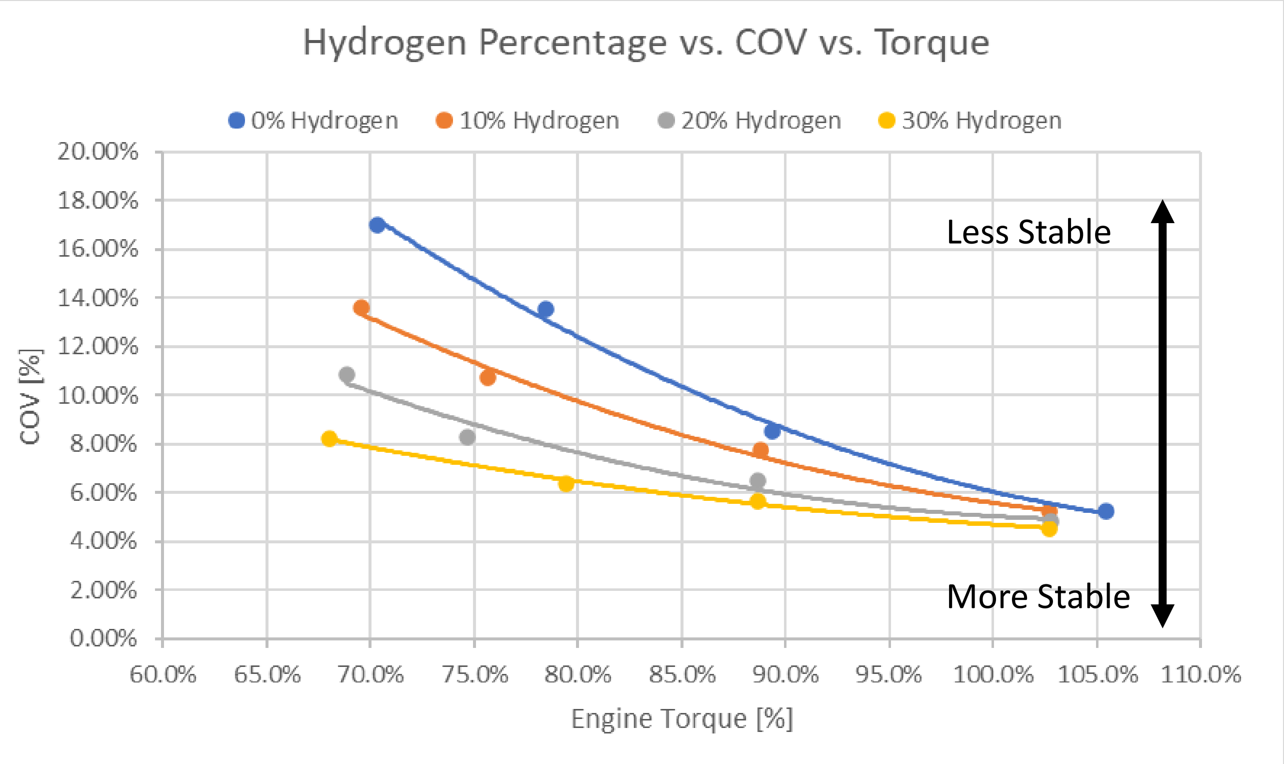


RESULTS – 70% ENGINE TORQUE

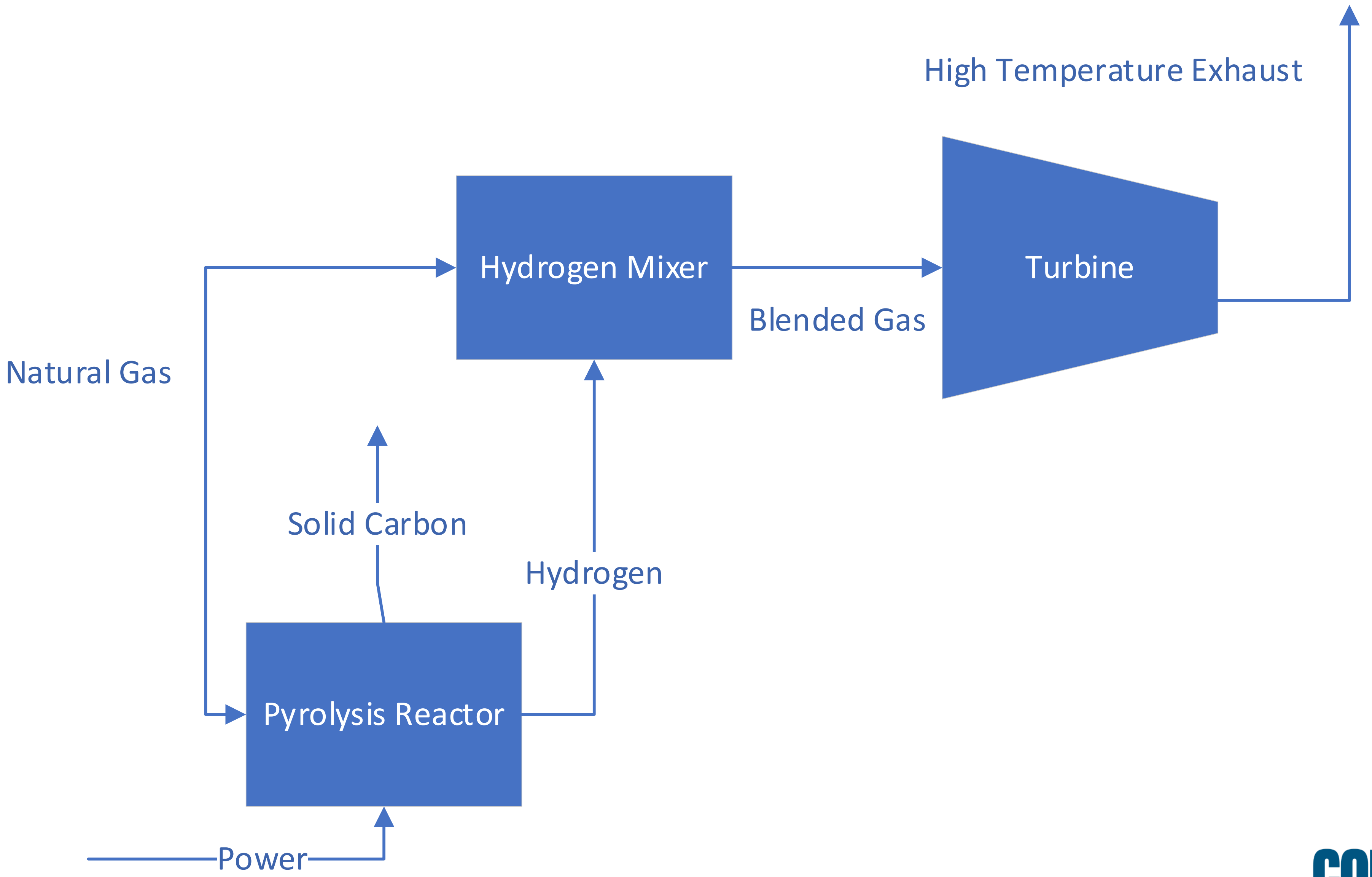


RESULTS – COMBUSTION STABILITY





NEXT STEPS – PYROLYSIS



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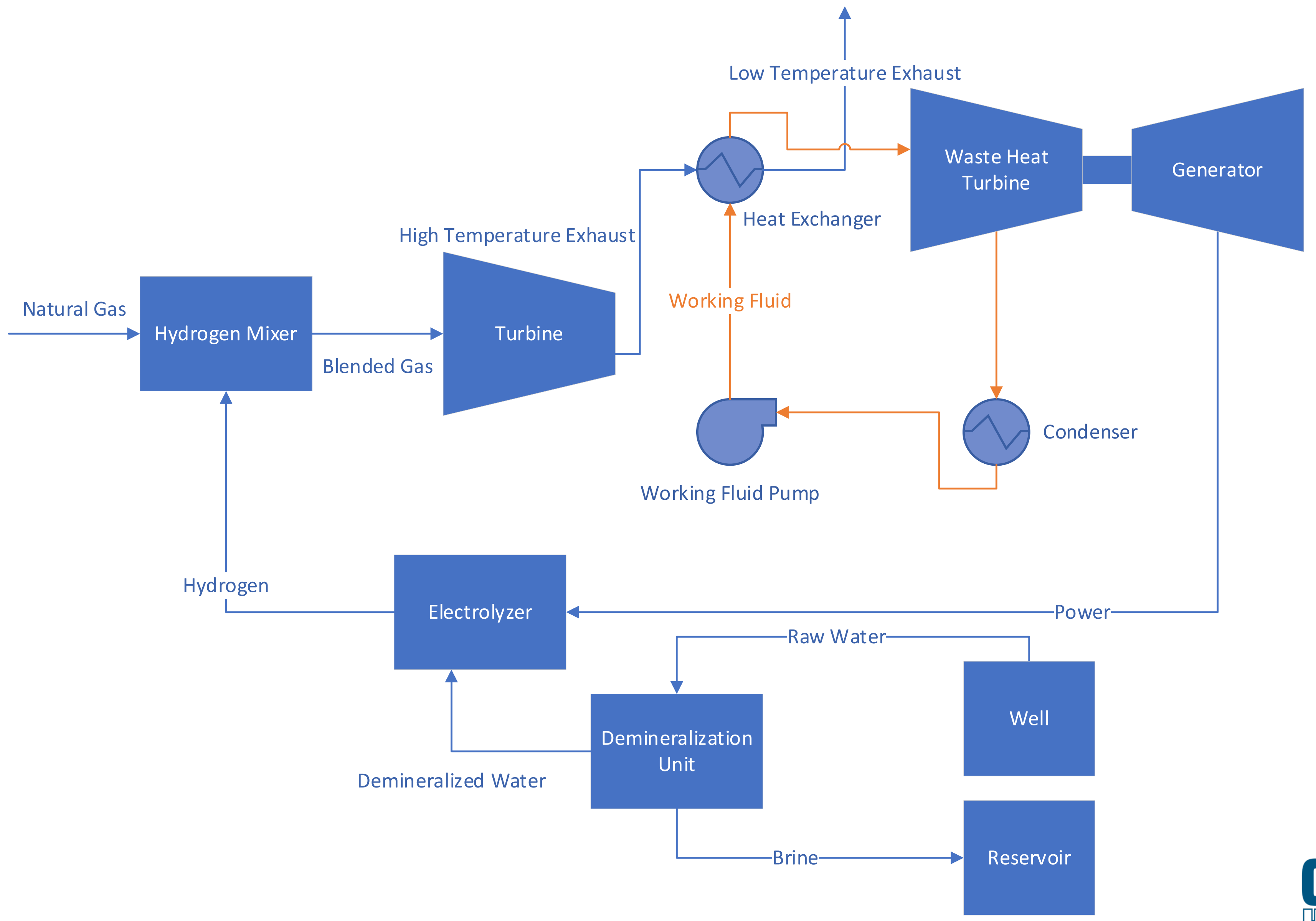
NEXT STEPS – WASTE HEAT TO ELECTROLYSIS



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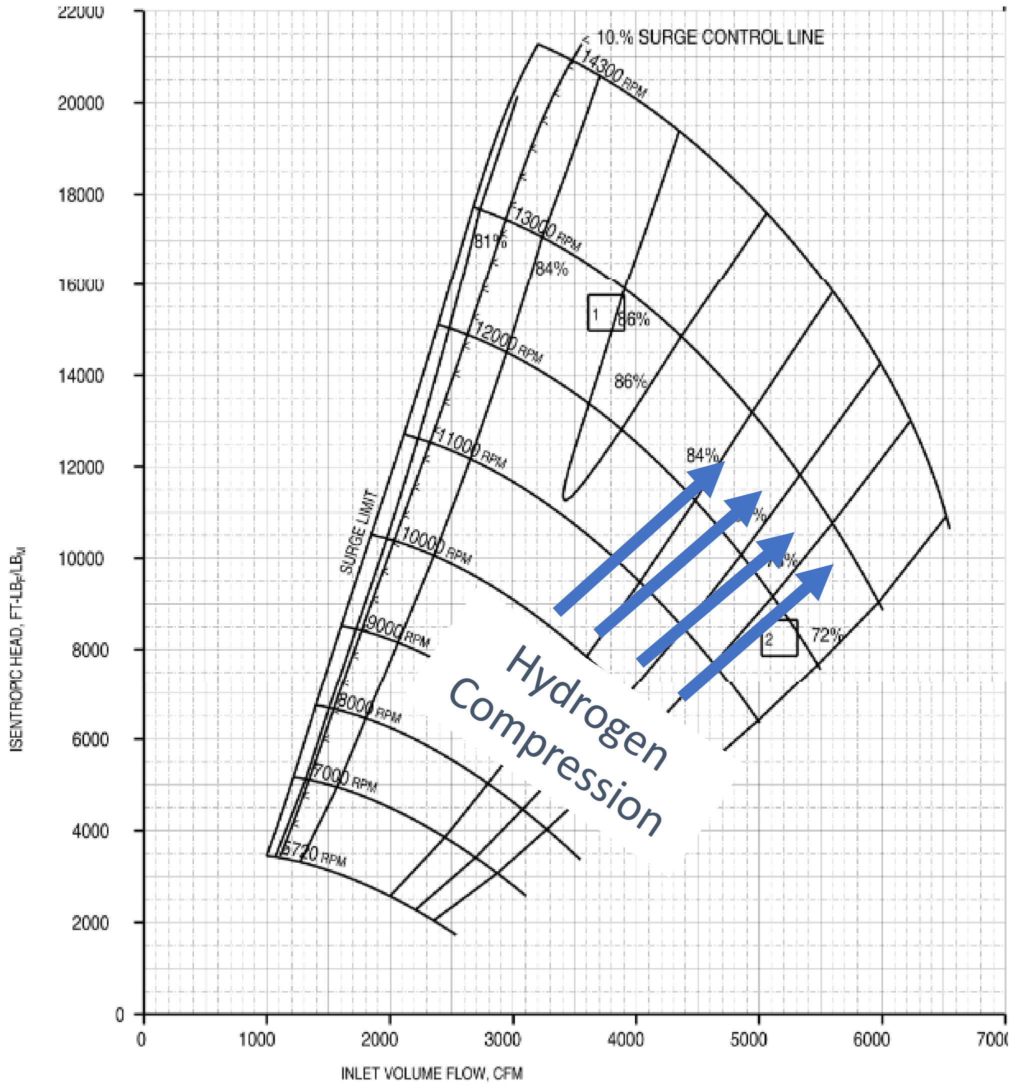
CONSIDERATIONS AROUND COMPRESSION

Major Component	Maximum % Hydrogen or Other Limiting Threshold
Building General Safety Requirements	20%
HAC Zone	20%
Gas Detectors with Semi-Conductor Technology	10%, recalibrate
Reciprocating Compressor seals, valves, lubrication and packing	20%, if components and compressor less than 20 years old
Centrifugal Compressor seals, including dry gas seals	20%
Gas Turbines and Enclosures	5%
Gas Engines	5%
Filtration or Separation Pressure Vessels	20%
Boilers (not modified for low NOx)	10%
Pulsation Bottles	Depends on the gas composition. % H_2 limit is the % that results in a 5% change in SOS
Vortex-Shedding	3%
Blowdown System	Depends on the pipe geometry and gas composition. % H_2 limit is the % that results in a 3% change in flow velocity
Non-pressure reducing valves	10%, depending on allowable leakage
Gas Hydraulic Actuators	5%
Meters	10%
Water Analyzers	20%, recalibrate
Pressure and Temperature Sensors	20%
Piping sealing elements	20%, depending on allowable leakage levels



CONCLUSION