Wabash Hydrogen Negative Emissions Technology Demonstration

DE-FE-0031994

2024 FECM Spring R&D Project Review Meeting – April 25, 2024

RESOURCES

US Department of Energy, Federal Funding Status

Year	Department	Amount	Status	Links, Notes
2018	DOE, FECM via Illinois Geological Survey	Geological Characterization		

DE-FE0031994 – Project Objectives

Develop and design all aspects of the scope, cost, schedule and investment case for Front End Engineering Design (FEED)

- Complete set of FEED deliverables
- 100% hydrogen capable combustion turbine
- Design for geological sequestration wells and infrastructure (Pipeline)
- High volumetric energy storage via Ammonia (NH_3)
- Fastest to Commercialization
- Enhanced FEED & final vendor selection

WV RESOURCES

Major Technical Achievements

Lowest Levelized Cost of Energy (LCOE) of the 21st Century Power Plant: Zero Carbon and Dispatchable

Revitalize existing infrastructure and design development for accelerated commercial deployment

Near zero emissions with 97%+ total carbon capture vs. 90% goal.

Net negative carbon lifecycle intensity achievable with biomass feedstock utilization

Flexible operations that include dispatchability and turndown, along with hydrogen storage in the form of Ammonia

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Major Commercial Achievements

Redevelopment of a coal community

- Creatively utilizes land below the SMCRA remediated coal mines for CCS
- Repurposing the gasification creates long term job security for previous miners and power plant workers

Develop private capital market support for commercial demonstration

- Continuous multi year education to banks and private funds has paved a path for potential private capital involvement alongside federal funds

Comprehensive financial modelling that incorporates environmental attributes

- Incorporate non-traditional elements such as financial responsibility aspects of Class VI
- Risk factors around lifecycle intensity and related revenues –
  - Net 0, 45 V vs Q, Regionality, Additionality, Hourly Matching
- Biomass / H2 still a viable pathway
- Embed risk management around claw backs of incentives

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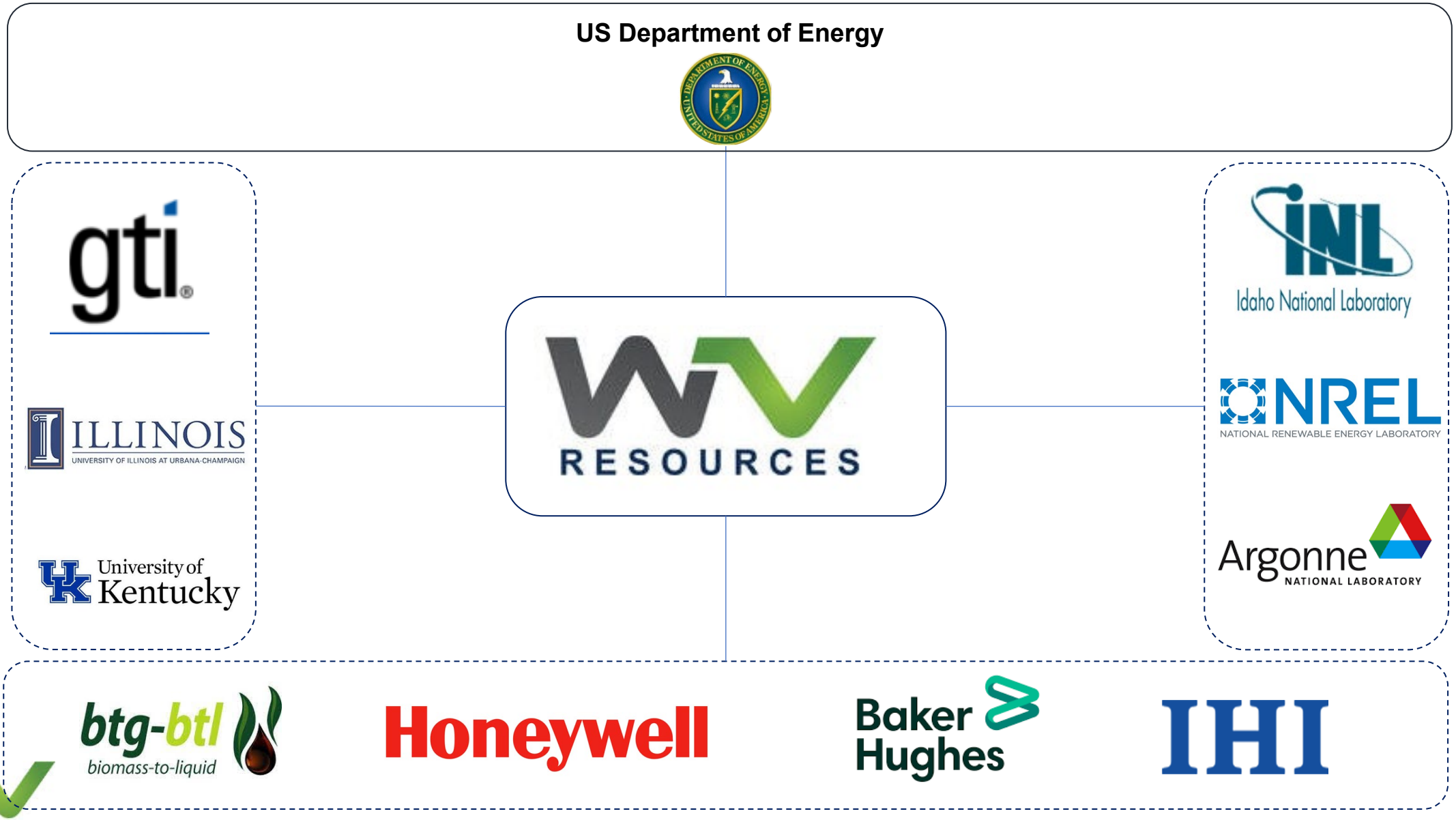
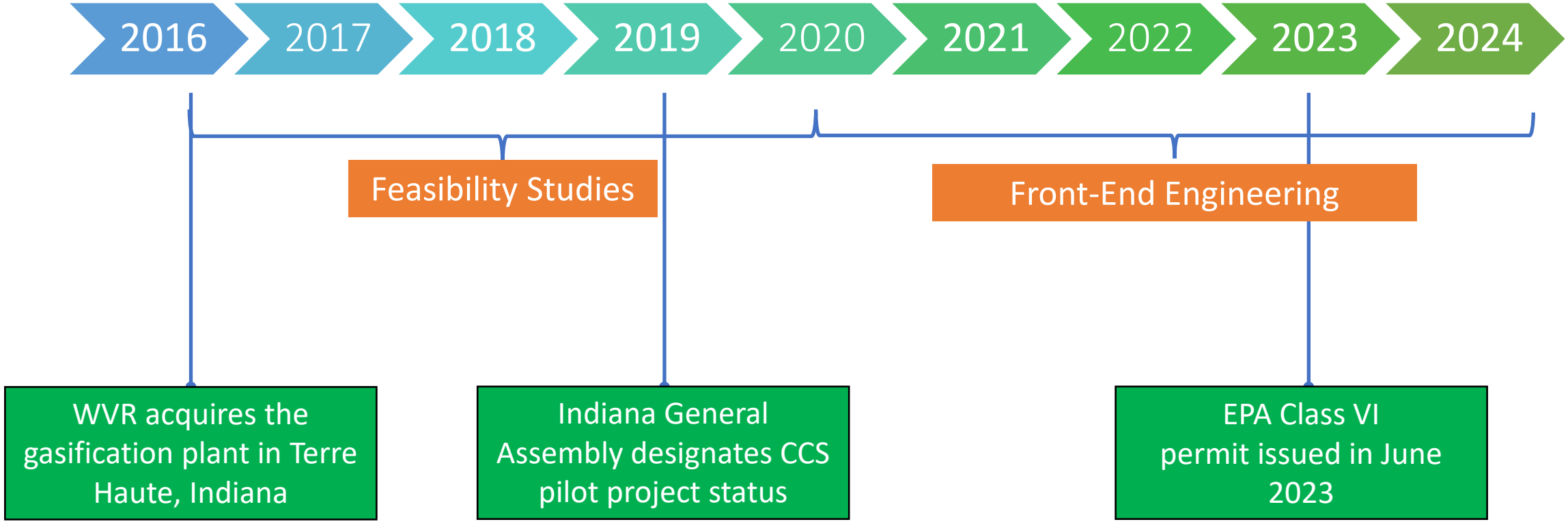
DOE PROJECT PARTNERSHIPS



Project Timeline

WVR is the most advanced hydrogen and ammonia project in the country. Strong federal support demonstrated throughout the development phase via high-risk capital investment.



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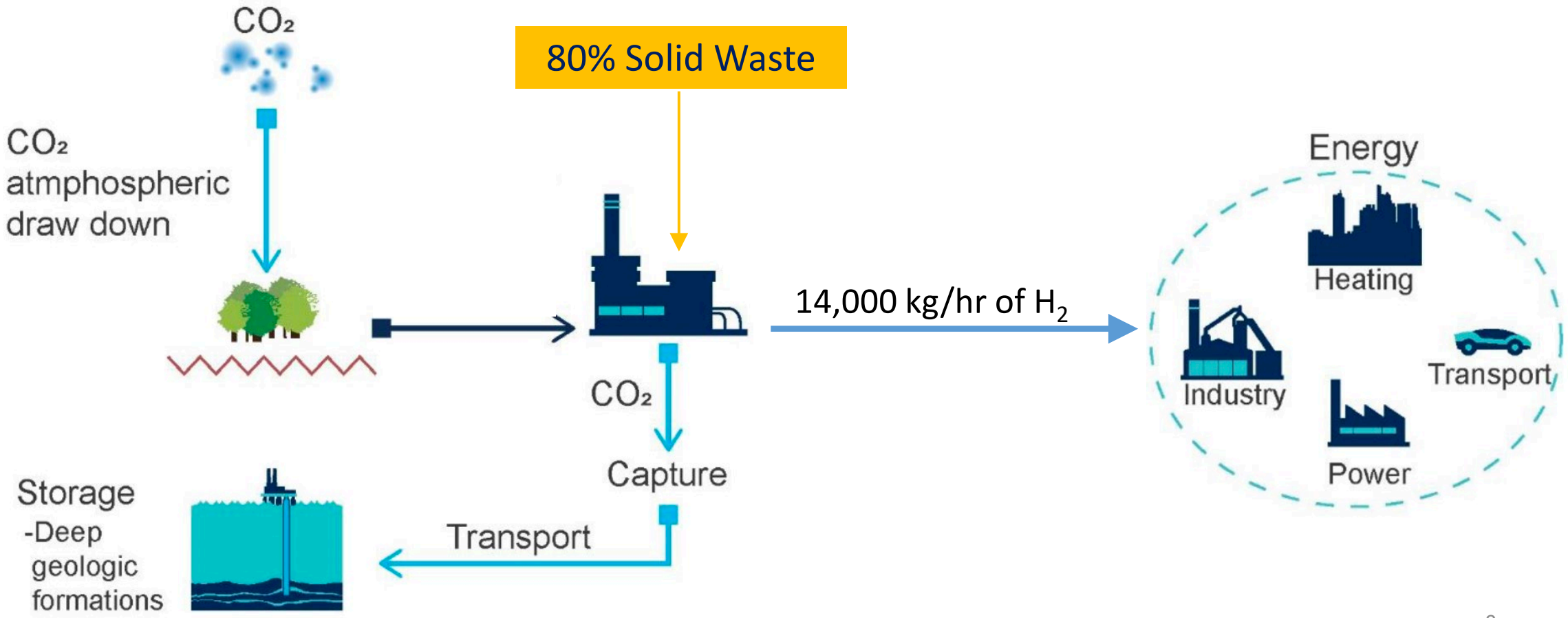
Bioenergy + Solid Waste = Carbon Negative Pathway

Argonne National Lab (ANL) conducted detailed lifecycle carbon analysis. WVR project achieves negative carbon intensity by blending 20% biomass as feedstock.



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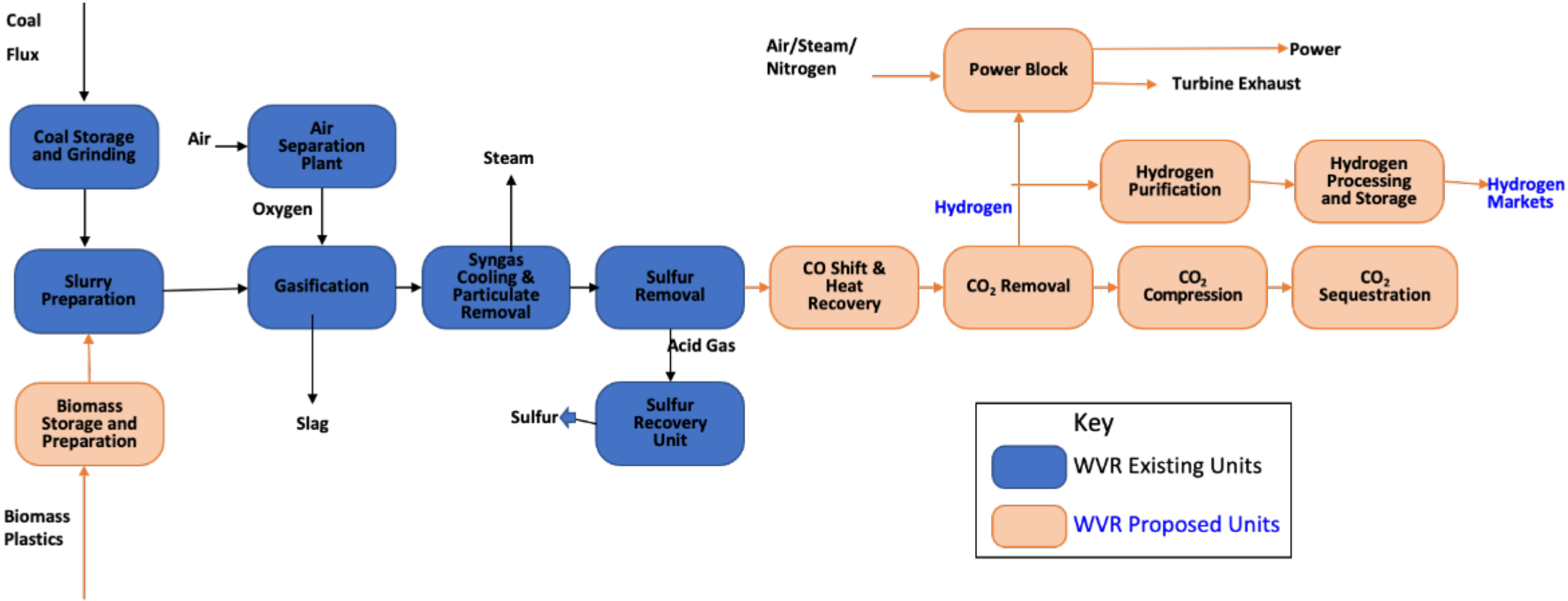
FEED Scope: Block Flow Diagram

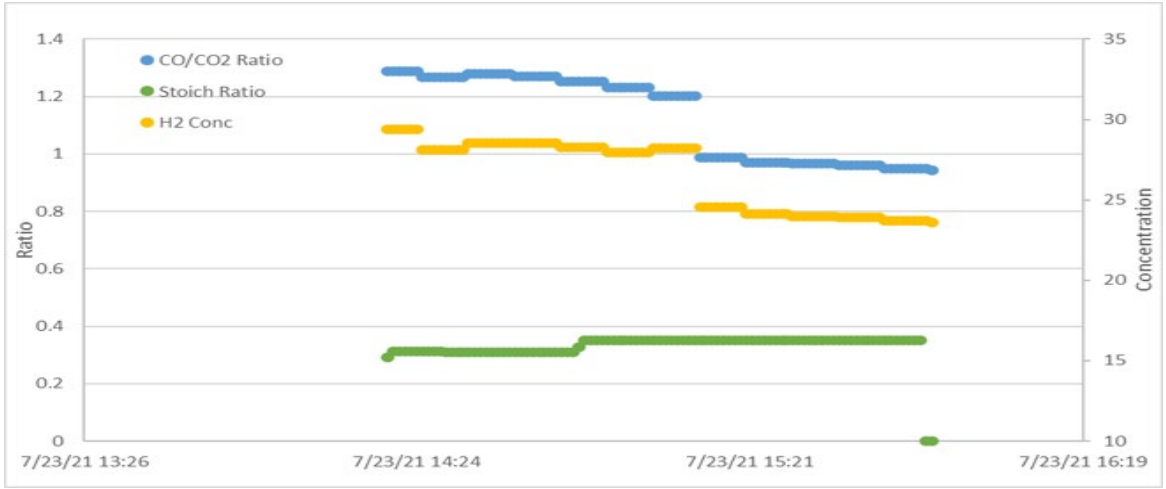


BP1 Accomplishments

Net Zero / Biomass Strategy

- Biomass Testing and Analysis
  - Various types of biomasses feedstocks considered include corn stover, corn silage, and forest residue.
  - Pre-Treatment options evaluated were steam explosion, torrefaction, and fast pyrolysis.
  - Slurryability requirements (% solids).
- Pyrolysis Oil
  - Two different bio-oil ratios – based on HHV
    - 12% bio-oil
    - 18% bio-oil
- LCA Requirements
  - 20% by weight of fast pyrolysis bio-oil with sequestration to achieve net zero

Trial	Petcoke (wt%)	Biomass (wt%)	Total Solids (wt%)	Biomass	Results	Notes
1	56.0%	5.2%	61.2%	SE		Mixture became hard / un-pumpable mixture after < 10 sec
2	20.0%	1.9%	21.9%	SE		No noticeable issues
3	20.0%	5.6%	25.6%	SE		No noticeable issues
4	29.0%	5.4%	34.4%	SE		No noticeable issues
5	39.0%	5.3%	44.3%	SE		Mixture starting becoming viscous after < 24 hrs
6	48.0%	5.1%	53.1%	SE		Mixture became hard / un-pumpable after soon after Completely hard after < 24 hrs
7	47.0%	7.8%	54.8%	SE		Mixture became hard / un-pumpable soon after adding the biomass Completely hard after < 24 hrs
8	44.0%	3.0%	47.0%	TORR		Torrified wood, still appeared pumpable after ~24 hrs
9	43.0%	4.8%	47.8%	TORR		Torrified wood, still appeared pumpable after ~24 hrs
10	50.0%	7.5%	57.5%	TORR		Torrified wood, became un-pumpable soon after adding biomass

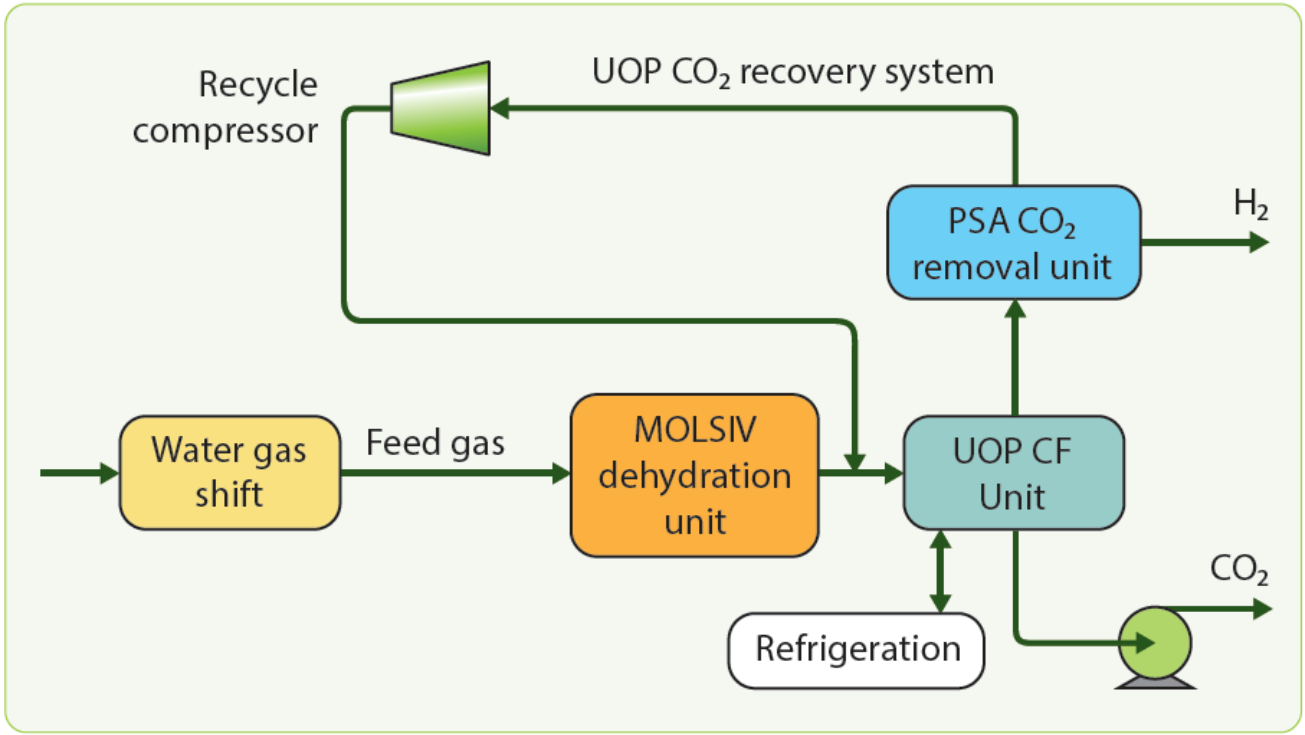


Carbon Capture Technology Selection

Status	Technologies Evaluated

Final Selection: UOP Dehydration, Fractionation, PSA

- Modularized/Smaller Plot
- Lower CAPEX
- Low Steam Consumption
- Meets requirement for dry CO_2 and Hydrogen



Status	

Status	Class VI Permit Requirement

BP2 Accomplishments

Technical Accomplishments

Completed Tasks 2023

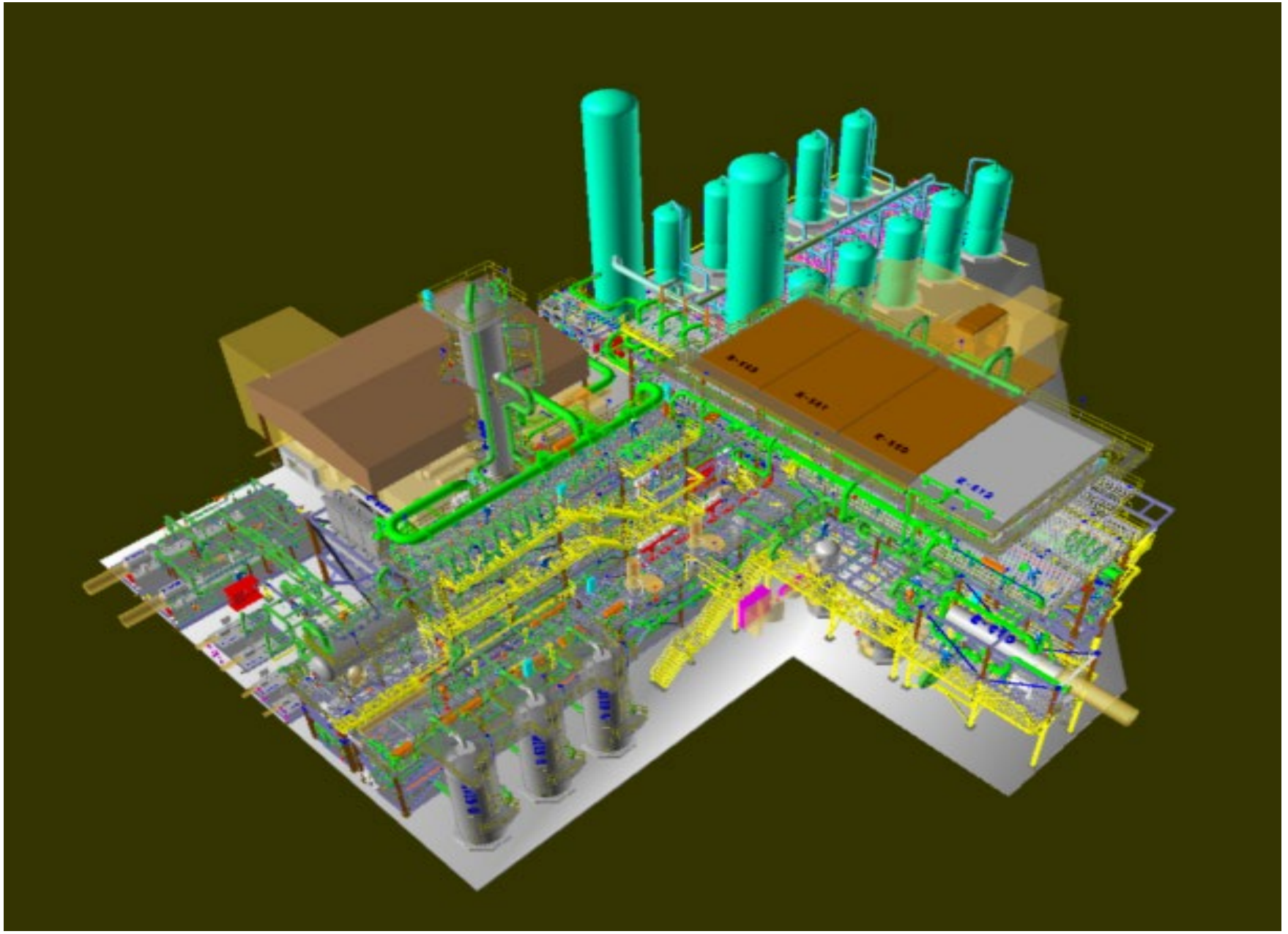
Fast Pyrolysis FEED completed
100% Hydrogen Power Block FEED completed
Water Gas Shift, H_2 purification and CO_2 capture FEED completed
CO_2 pipeline routing and injection well design complete
Gasification inspections complete

Completed Tasks 2024

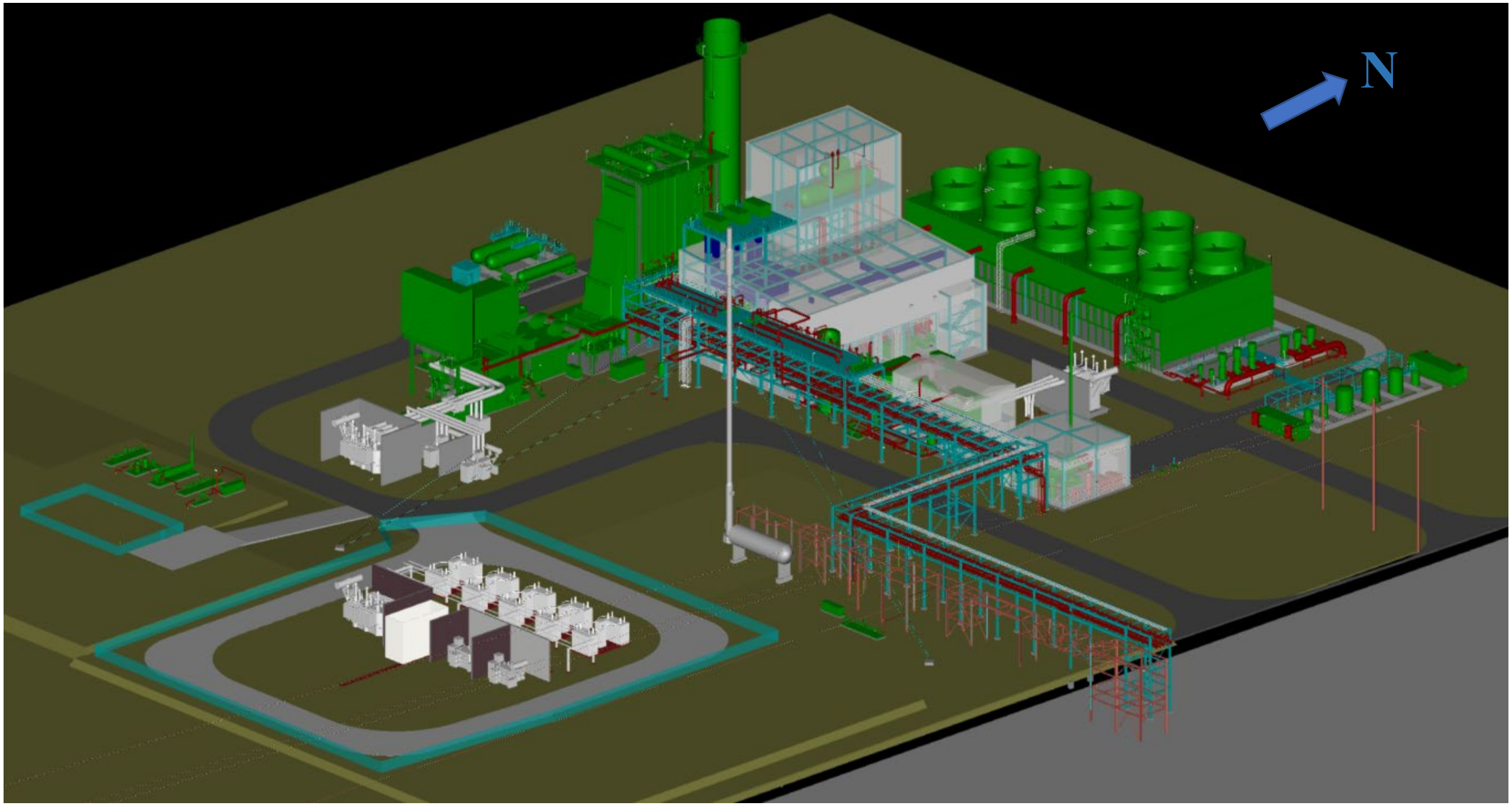
Gasification BOP integration
Hydrogen Storage (Ammonia) FEED - HAZOP
Final PDRI
Overall FEED integration
Lifecycle Analysis

Final Report 80% Complete

Hydrogen Pant FEED 3D Model



Power Block FEED 3D Model



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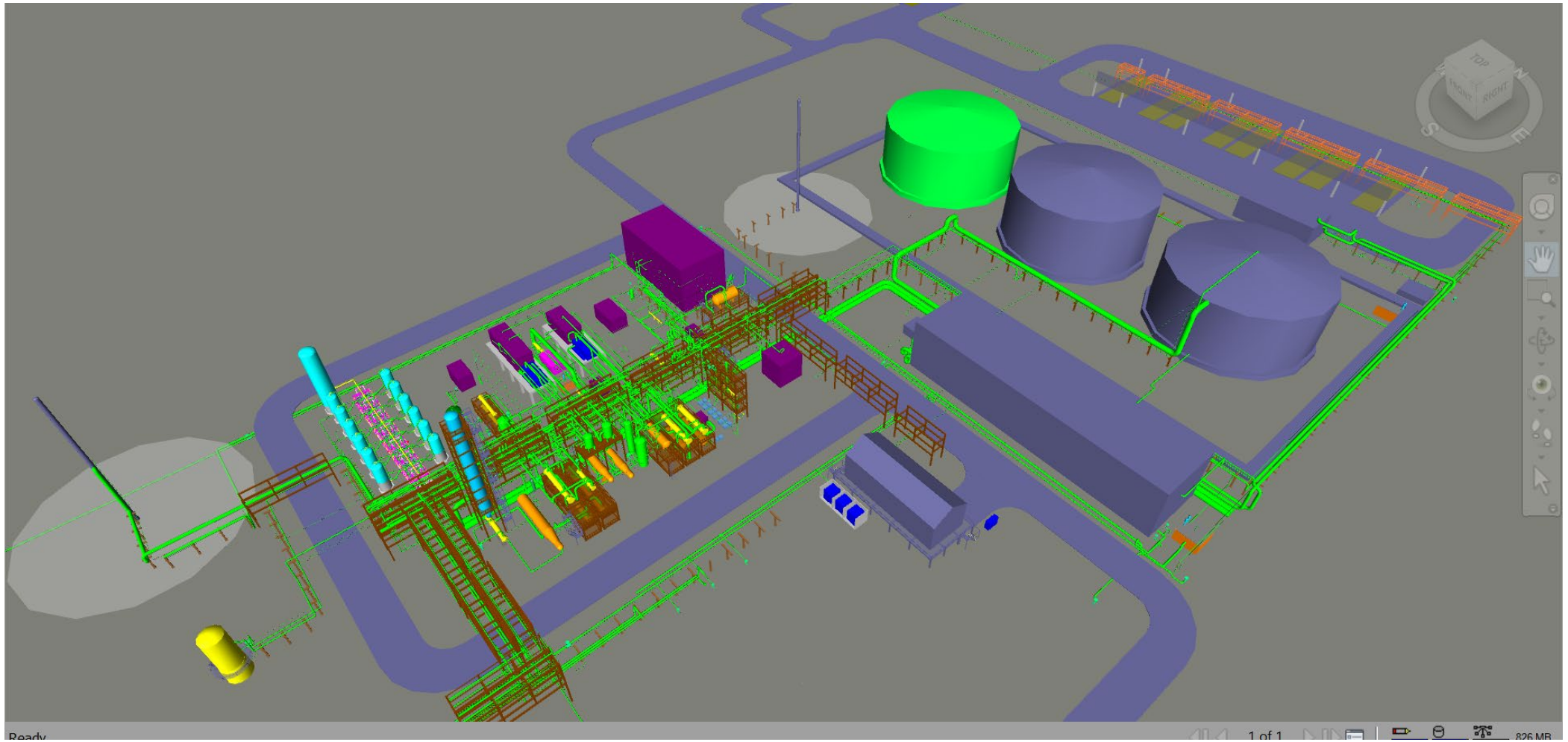
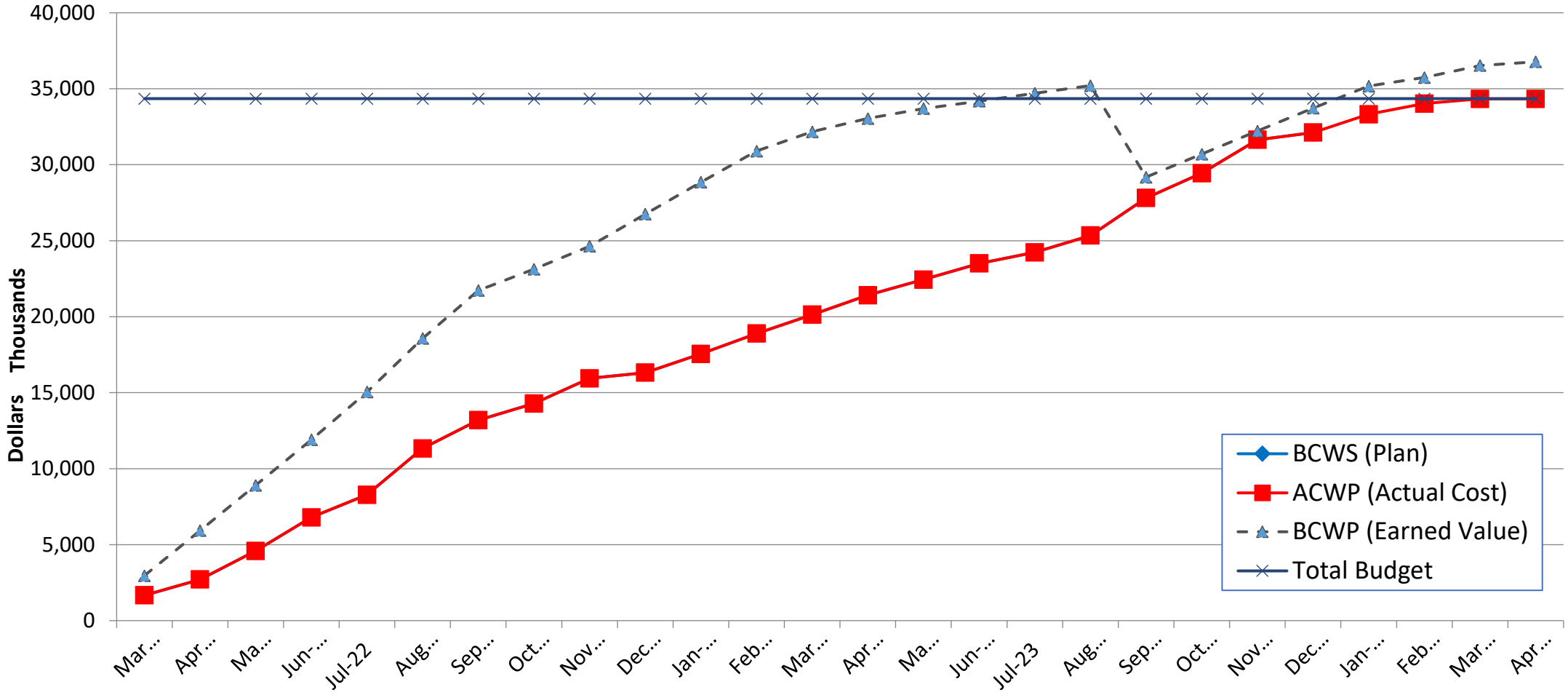
Ammonia Plant with Product Handling System FEED 3D Model

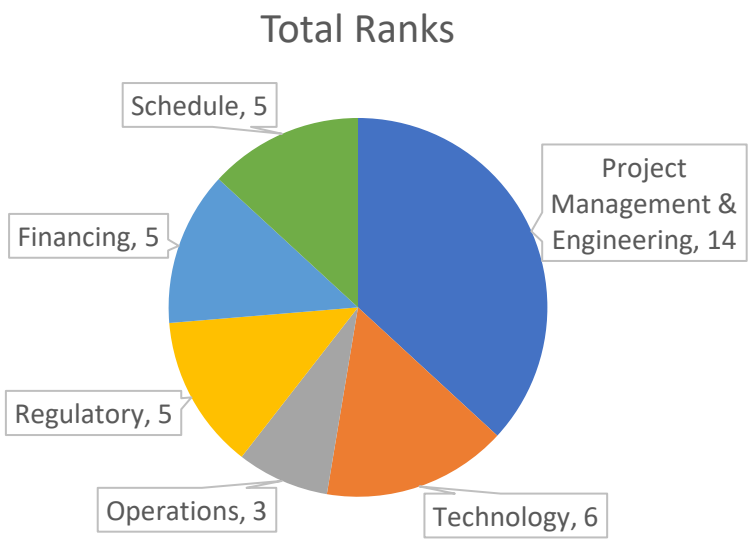


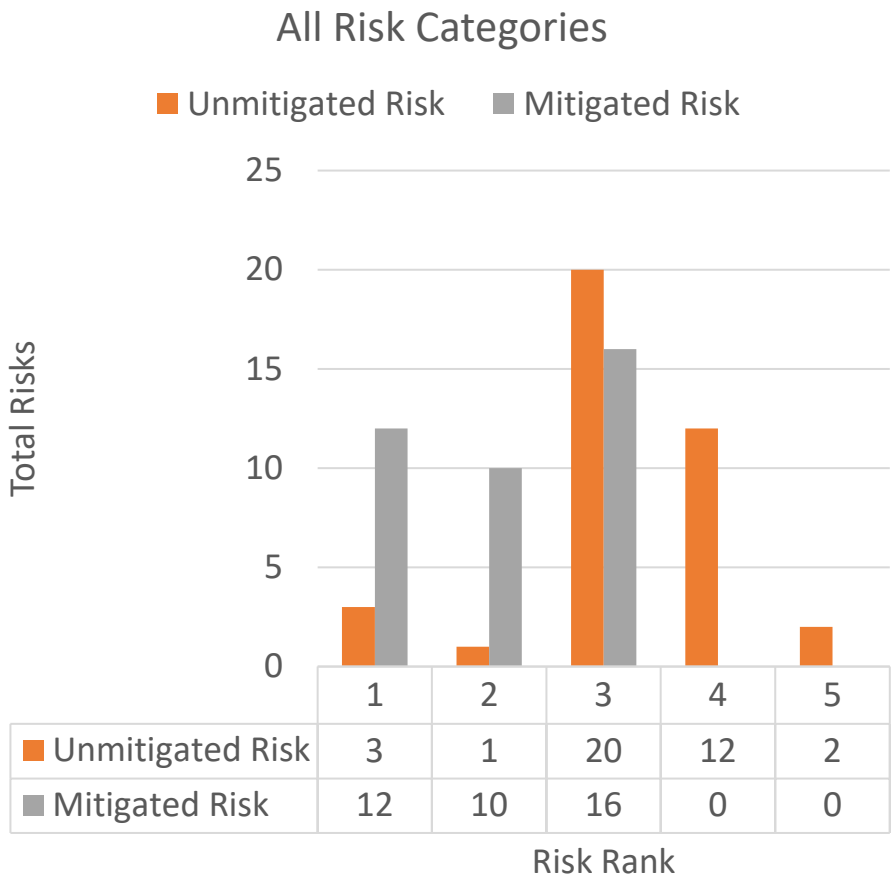
Project Controls Performance



Risk Management

	Unmitigated Risk						Mitigated Risk						Total Ranks
	1	2	3	4	5		1	2	3	4	5		
Project Management & Engineering	2	0	6	5	1		7	3	4	0	0		14
Technology	0	0	4	2	0		0	5	1	0	0		6
Operations	1	1	1	0	0		3	0	0	0	0		3
Regulatory	0	0	3	2	0		1	2	2	0	0		5
Financing	0	0	3	2	0		0	0	5	0	0		5
Schedule	0	0	3	1	1		1	0	4	0	0		5
All Risk Categories	3	1	20	12	2		12	10	16	0	0		38
RPI			3.24						2.11				





RESOURCES

Project Statistics

- ~85,000 WVH Hours
- ~215,000 Subrecipient & Vendor Hours
- 6 Full FEED packages
- Project Participants
  - BP1 – 44 contributors
  - BP2 - 85 contributors (42 additions)

THANK YOU