Wabash Hydrogen Negative Emissions Technology Demonstration

DE-FE-0031994

2023 FECM Spring R&D Project Review Meeting – April 19, 2023

WABASH VALLEY RESOURCES

US Department of Energy, Federal Funding Status

	Department	Amount	Status	Links, Notes
2018	DOE, FECM via Illinois Geological Survey	Geological Characterization	✓	Subsurface Geological Characterization
2020	DOE, FECM	Carbon Negative Hydrogen and Power Generation	✓	Carbon Negative Hydrogen FEED

DOE: US Department of Energy
FECM: Fossil Energy and Carbon Management

DE-FE0031994 – Project Objectives

Develop and design all aspects of the scope, cost, characteristics and investment case

- Complete set of FEED deliverables
- 100% hydrogen capable combustion turbine
- Detailed design for geological sequestration wells and infrastructure
- High volumetric energy storage via Ammonia (NH_3)
- Fastest to Commercialization

WABASH VALLEY RESOURCES

Major Technical Achievements

Lowest LCOEs 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 with biomass feedstock utilization

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

WABASH VALLEY RESOURCES

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
- Embed risk management around claw backs of incentives

DOE PROJECT PARTNERSHIPS

US Department of Energy

WV RESOURCES

gti

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

University of Kentucky

INL
Idaho National Laboratory

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Argonne
NATIONAL LABORATORY

btg-btl
biomass-to-liquid

Honeywell

Baker Hughes

IHI

WABASH VALLEY RESOURCES

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.

2016 → 2018 → 2019 → 2021 → 2023 → 2024

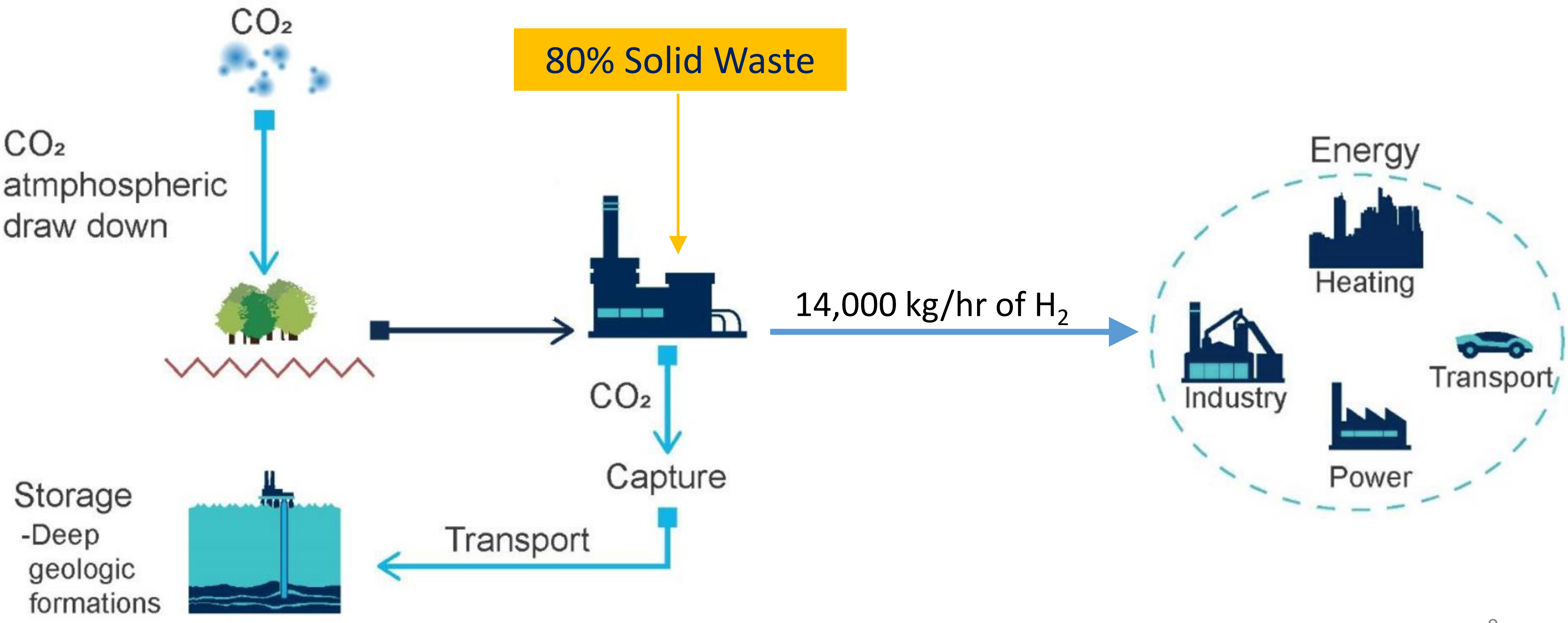
Feasibility Studies (2016–2019)

Front-End Engineering (2019–2024)

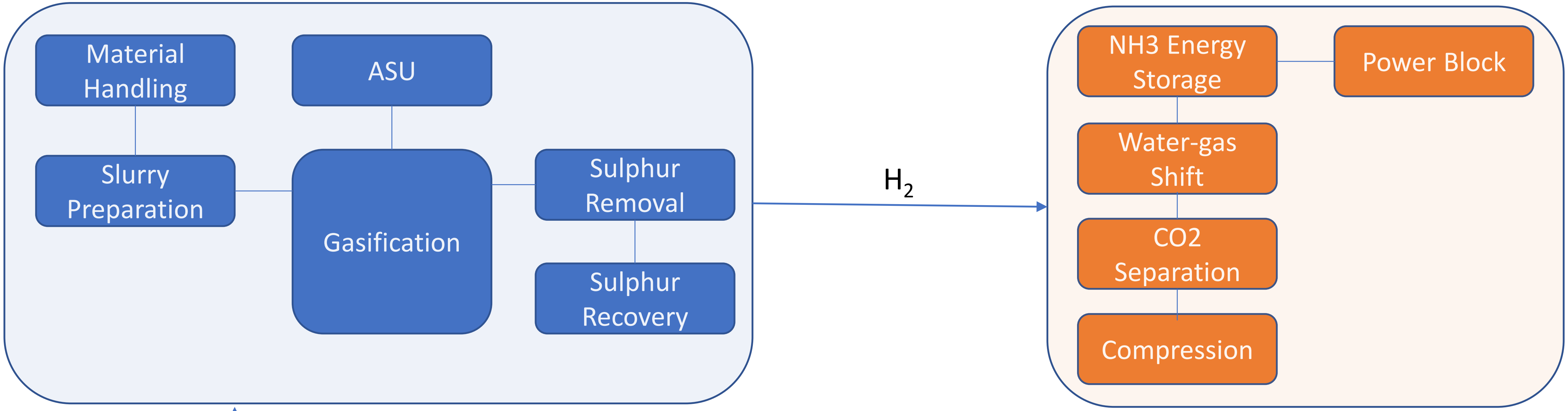
- 2016: WVR acquires the gasification plant in Terre Haute, Indiana
- 2019: Indiana General Assembly designates CCS pilot project status
- 2023: EPA Class VI permit anticipated to be issued by June 2023

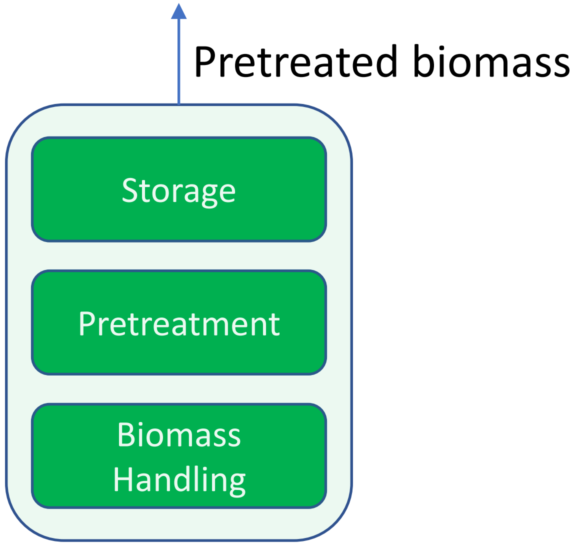
Bioenergy + Solid Waste = Carbon Negative Pathway

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



FEED Scope: Block Flow Diagram





ACHIEVEMENT HIGHLIGHTS

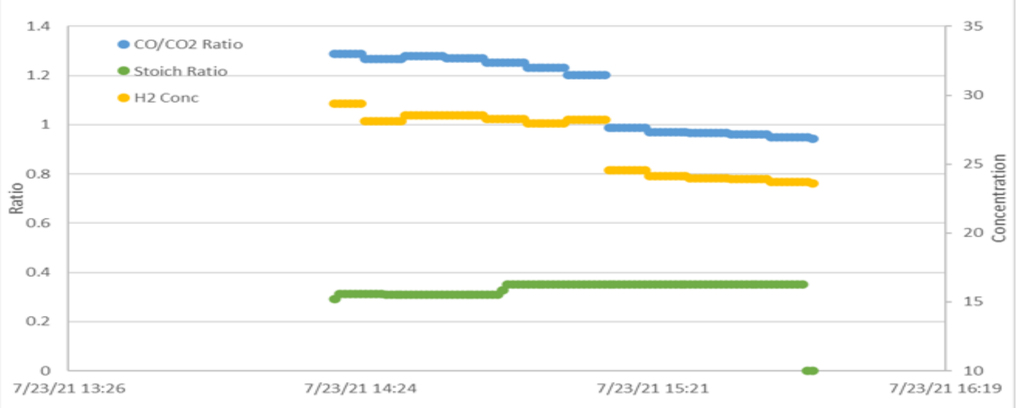
- Pretreatment of biomass for entrained flow gasification
- 100% Hydrogen capable combustion turbine
- High volumetric density energy storage via Ammonia (NH3)

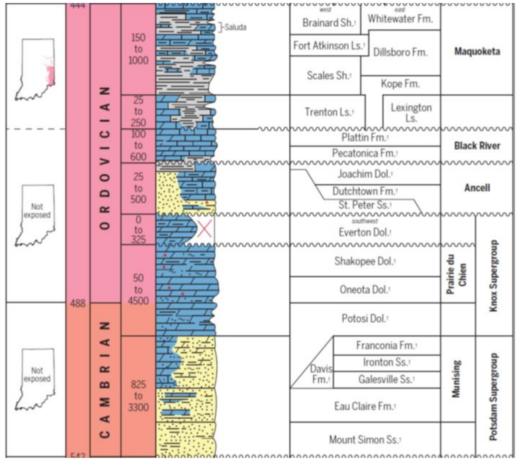
BP1 Accomplishments

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

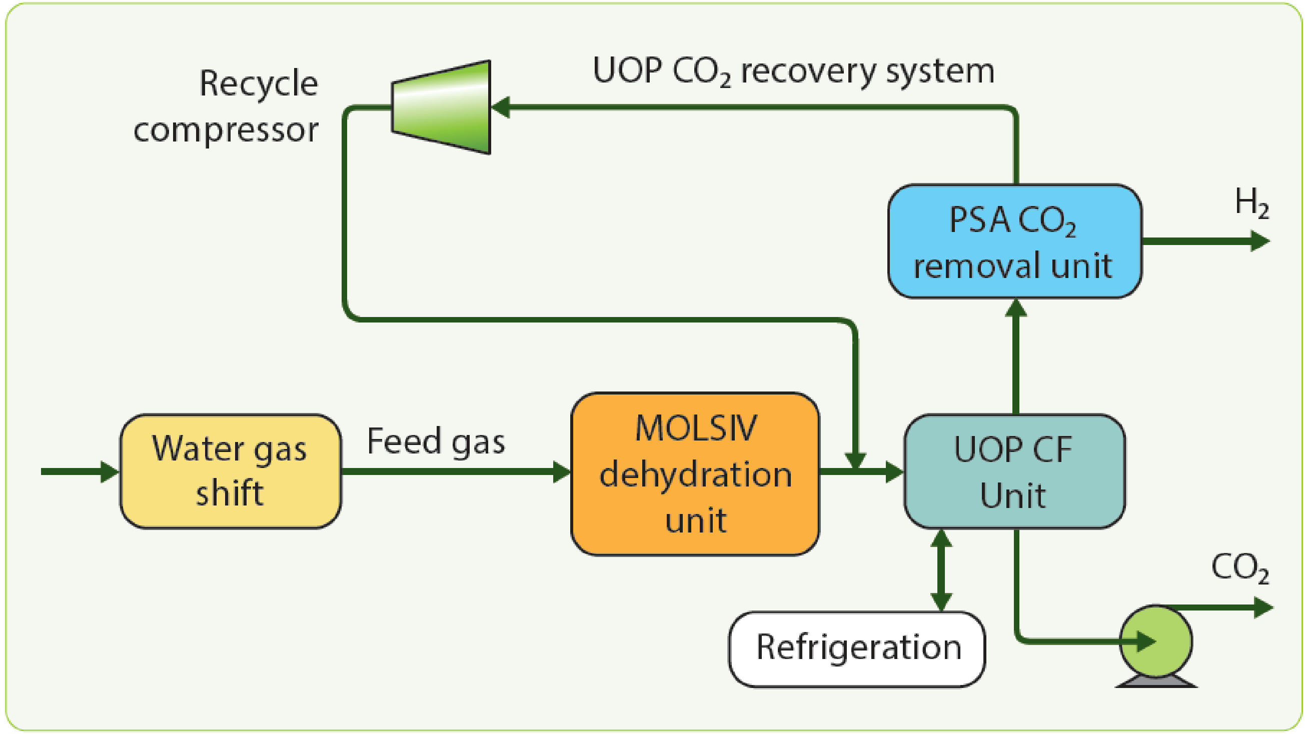
Trial	Petcoke (wt%)	Biomass (wt%)	Total Solids (wt%)	Biomass	Results	Notes
1	56.0%	5.2%	61.2%	SE		Mixture became hard / un-pumpable mixture after < 10 sec
2	20.0%	1.9%	21.9%	SE		No noticeable issues
3	20.0%	5.6%	25.6%	SE		No noticeable issues
4	29.0%	5.4%	34.4%	SE		No noticeable issues
5	39.0%	5.3%	44.3%	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
✓	Amine (MDEA) based solvents (7 configurations modeled)
✓	CO_2 Fractionation
✓	Rectisol
✓	Selexol



Final Selection: UOP Dehydration, Fractionation, PSA

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

Hydrogen Storage Evaluation/Selection

Status	
☑	Liquid Organic Hydrogen Carrier (LOHC)
☑	Liquid Hydrogen
☑	Ammonia
☑	Compressed Hydrogen

Of all the storage options, Ammonia was the most practical, with no TRL barriers and with the highest volumetric density.

FEED design incorporates all UIC regulatory needs

Status	Class VI Permit Requirement
✓	Extensive site characterization
✓	Injection well construction requirements for materials that are compatible with and can withstand contact with CO_2 over the life of a project
✓	Comprehensive monitoring program that address all aspects of well integrity, CO_2injection and storage, and ground water quality during the injection operation and the post-injection site care period
✓	Financial responsibility requirements assuring the availability of funds for the life of a project (including post-injection site care and emergency response)
✓	Reporting and recordkeeping requirements that provide project-specific information to continually evaluate Class VI operations and confirm USDW protection

BP2 Accomplishments

Technical Accomplishments

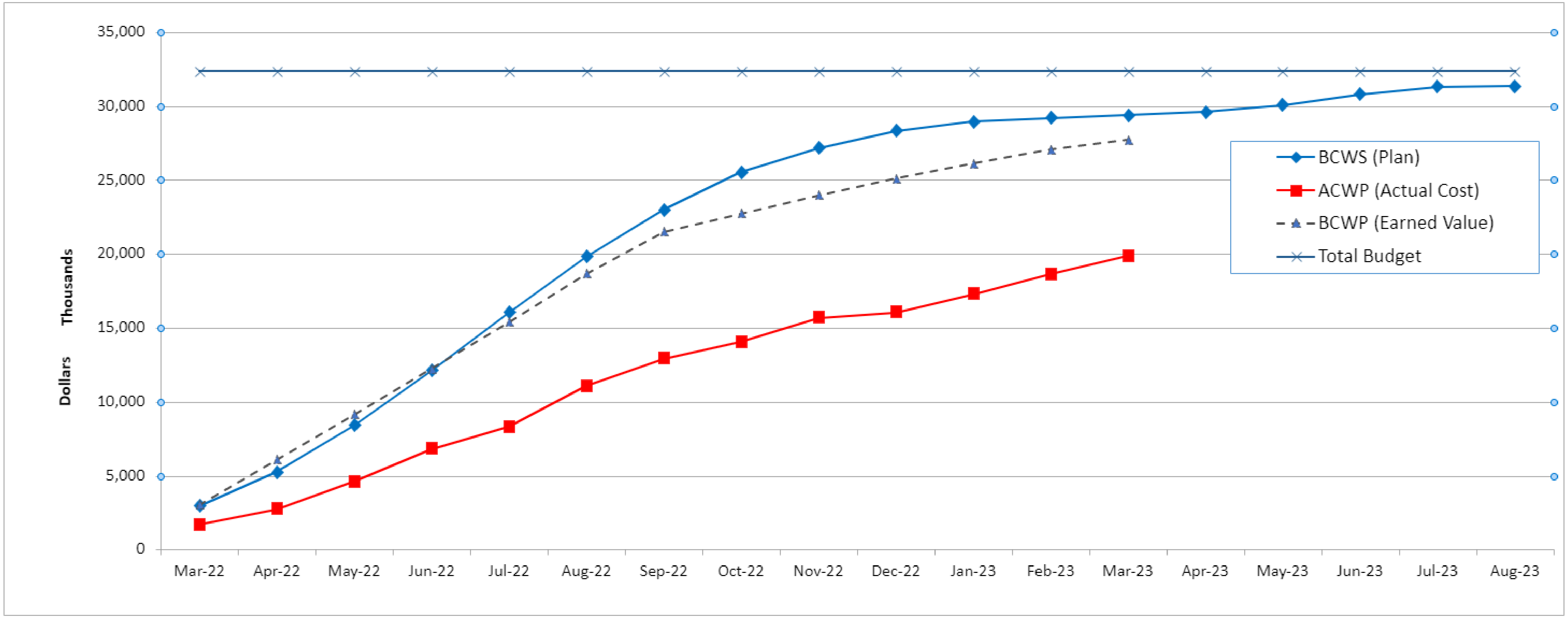
Completed Tasks thus far..

✓	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

In Progress Tasks..

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

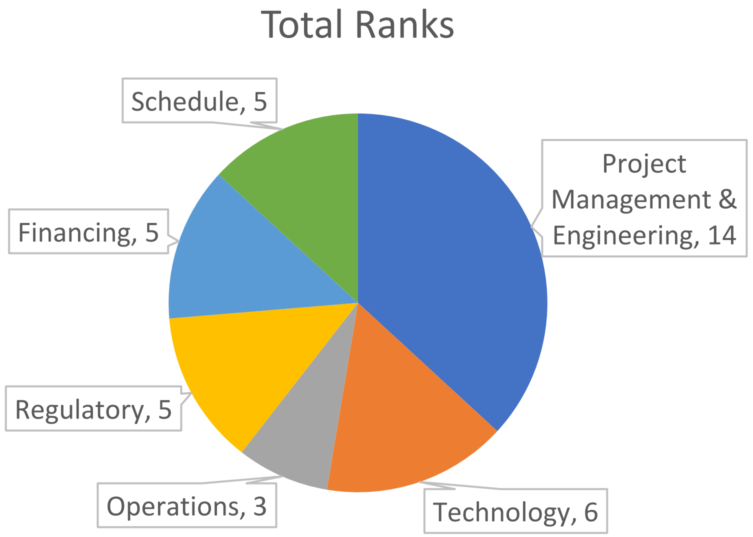
Project Controls Performance

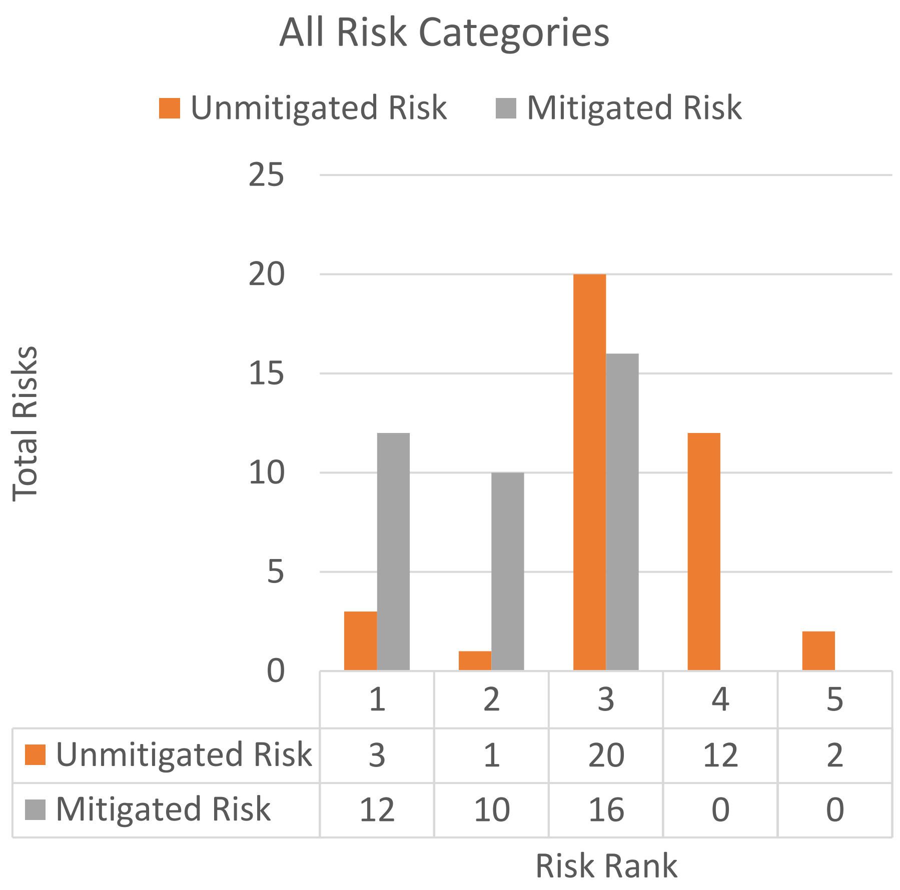


No- Cost Time Extension Request Is In Progress

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				





THANK YOU