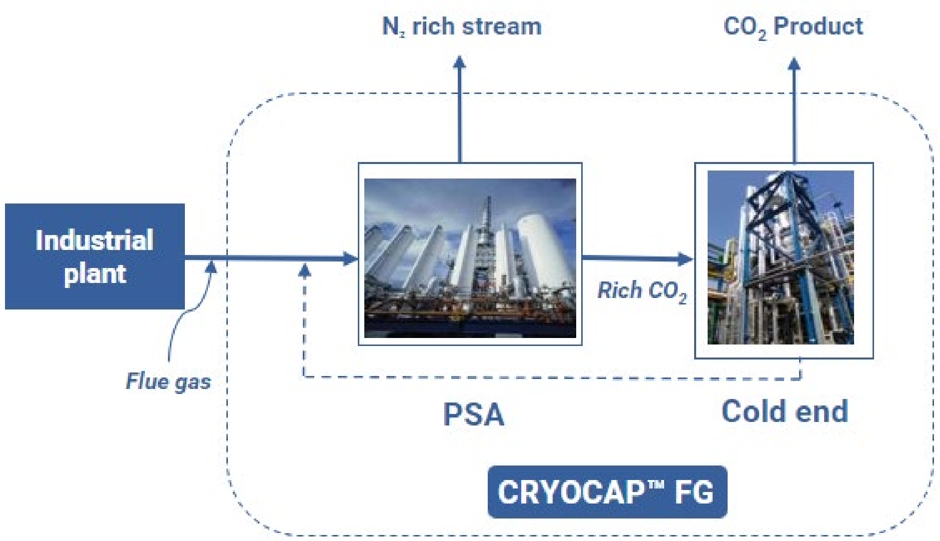
Industrial Carbon Capture from an Existing Hot Briquetted Iron Manufacturing Facility Using the Cryocap™ FG Process (DE-FE0032221)



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2024 FECM / NETL Carbon Management Research Project Review Meeting
August 6th, 2024

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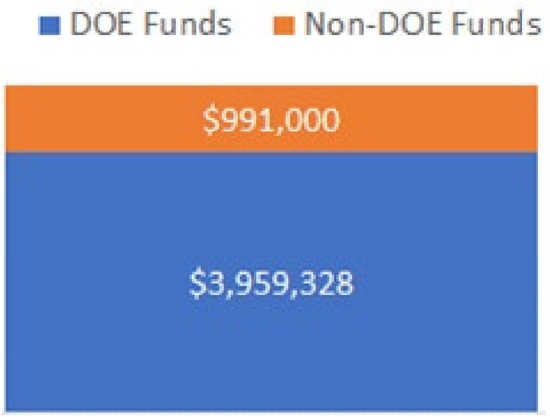
Project Overview and Objectives

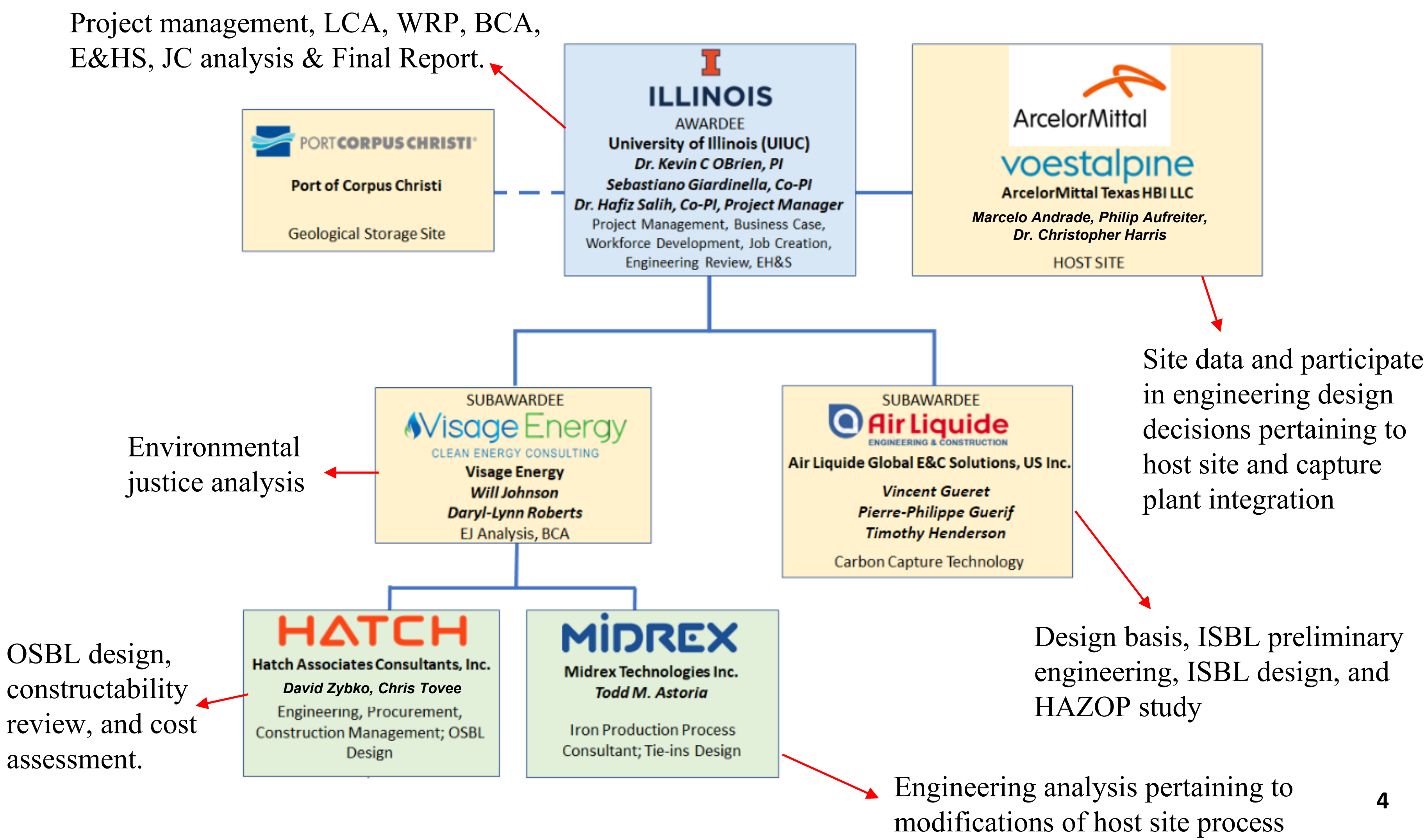
- Total Funding: $4,950,328
  DOE: $3,959,328
  Non-DOE: $991,000
  Cost Share: 20%
- Performance Period:
  April 1, 2023– June 30, 2025*
  18 months, 1 Budget Period



- Execute and complete front-end engineering and design (FEED) studies for a commercial-scale, carbon capture project that separates 95% of the main carbon dioxide (CO_2) emissions at a Hot Briquetted Iron (HBI) plant that emits approximately 1 million tonnes CO_2/year. The capture system is a Pressure Swing Adsorption (PSA) system assisted Cryocap™ technology.

*After pending No-Cost extension

Project Team Management Structure and Team Tasks



Prairie Research Institute UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN | NET ZERO CENTER of EXCELLENCE | ArcelorMittal | voestalpine | Air Liquide ENGINEERING & CONSTRUCTION | HATCH | MIDREX | Visage Energy CLEAN ENERGY CONSULTING | U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

Project Participants

Name	Organization
Hafiz Salih, Sebastiano Giardinella, Bajio Varghese Kaleeckal, Maholy Echeto Palmar, Mary Terese Campbell, Ryan Larimore, Vinod Patel, Jim Dexter, Jason Zhang	University of Illinois at Urbana Champaign
Marcelo Andrade, Philip Aufreiter, Anderson Morelato, Christopher Harris, Juan Aguilera, Elaine Chen	ArcelorMittal
Todd Astoria, Allison Sellers, Sean Boyle	Midrex
Vincent Gueret, Lindsey Turney, Timothy Henderson, Pierre-Philippe Guerif, Anh Dang, Marie Jacquemin, Vincent Lu, Kazeem Adeleke, Pamela Pellacoeur, Elia Corder	Air Liquide
Will Johnson, Daryl-Lynn Roberts	Visage Energy
David Zybko, Chris Tovee, Paul Towsey, Brian Rogers, Mark Slazinski, Ian Hardesty, Edward Warpotas, Fernando Sanchez, Branden Messina, Ben Collacott, Nicole Cavlovich	Hatch

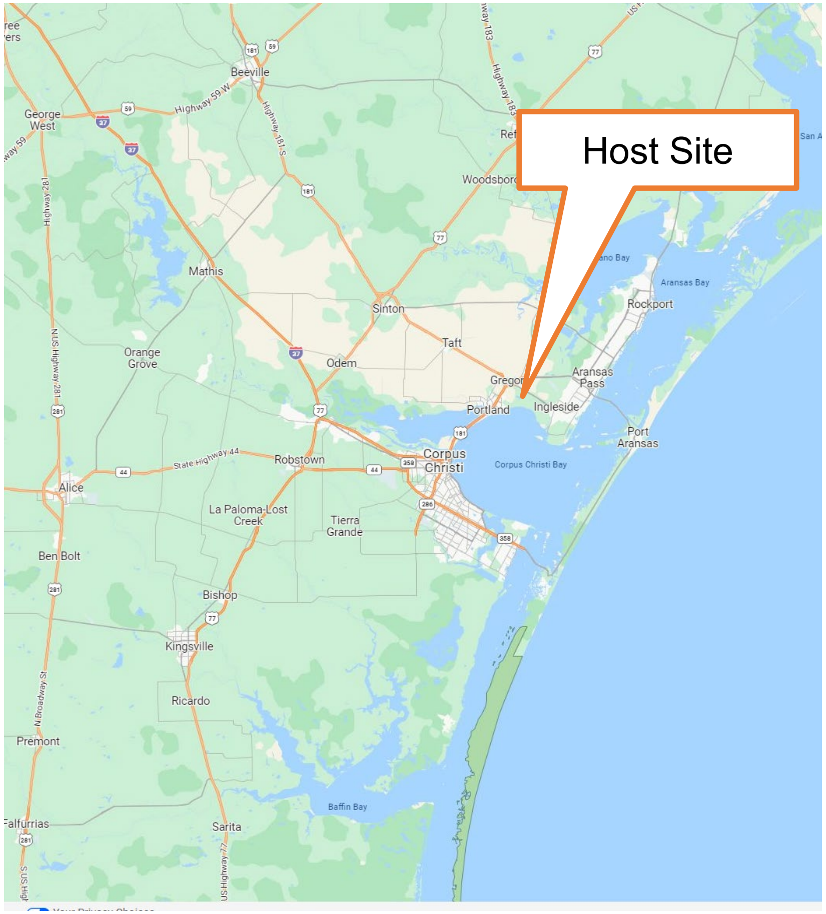
Host Site

ArcelorMittal Texas HBI

World’s largest and most state-of-the-art HBI Plant with annual production of 2.0 million metric tons of high-quality MIDREX®

ArcelorMittal Texas HBI Plant

- Largest and most state-of-the-art HBI plant in the world.
- Production: 2.0 million tonnes/year MIDREX® HBI. Approximately 1 million tonnes/year CO_2.
- Located within the Port of Corpus Christi Area.
- Site is located close to several potential storage sites in development within Port of Corpus Christi area



ArcelorMittal – Growth in USMCA

Corpus Christi, Texas - 2Mt HBI capacity connected to low cost nat gas

ArcelorMittal Texas – plans to double capacity

- Plant hit production records in 2023
- Plans under development to double HBI capacity and add CCS capability → low cost, ultra-low carbon metallics

Calvert - State of the art 5.3Mt finishing facility

Calvert – plans to double EAF capacity

- 1.5Mt EAF under construction, due for completion 2H'24
- Option to add a second 1.5Mt EAF at lower capex intensity
- Plan developed for Electrical steel

Mexico – 2.5Mt of DRI-EAF based flat production

Mexico – HSM utilization to increase

- Capacity utilization to increase in 2024

Mines Canada producing 25Mt of high quality iron ore concentrate

AMMC to supply our requirements for DRI units

- Converting BF pellet production to reach 10Mt/y DRI pellets capacity early 2026
- To supply needs at Canada and Texas operations and potential to export to Europe

Dofasco, Canada, 4.5Mt of highest quality flat steel capacity

Dofasco transitioning to DRI-EAF

- Dofasco transition to DRI-EAF steel advancing through FEED

The US (and the broader USMCA) is a strategic growth focus for ArcelorMittal

ArcelorMittal is a key supplier to critical domestic industry, including automotive, and is well positioned to capture the anticipated growth in domestic steel demand

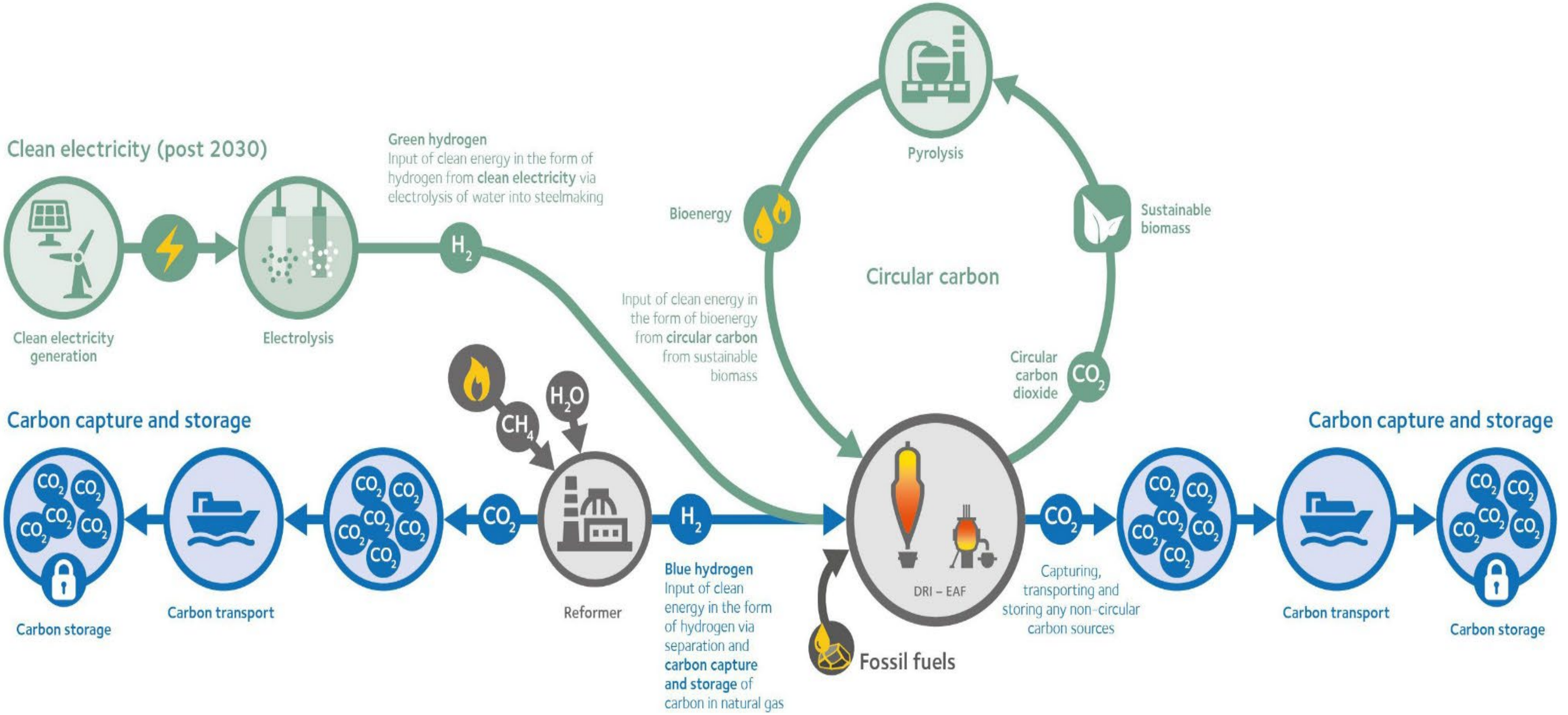
Growth and investment are being supported by favourable domestic policy which promotes domestic industry and competitiveness of domestic manufacturing

ArcelorMittal Decarbonization – North America Context

The steel industry is responsible for 7-9% of global CO_2 emissions.

- Availability of scrap today, scrap comprises 20-22% of global metallic inputs. IEA estimates 37% of steel will be produced via scrap based EAFs by 2030—increasing to ~50% by 2050.
- As such, Ore-based metallics are critical and will still be in demand as a scrap substitute.
- Capacity: Current and future announced US capacity additions ~16Mt, all EAF based with ~85% being flat rolled.
- Exports/Imports: US exports 15-20Mt obsolete scrap annually, but imports 2Mt prime scrap—prime scrap generation is abating
- In 2021 US imported 6Mt of pig iron and 1.7Mt of DRI/HBI.

ArcelorMittal Decarbonization Pathways



ArcelorMittal Decarbonization Projects

Strengths & advantages:

- Existing EAF footprint → 36 EAFs in the group (including JVs)
- Existing DRI capabilities → we are the world's largest DRI producer
- Innovation → R&D capabilities supporting "smart carbon" steel making technologies; announced plans to build industrial-scale direct electrolysis plant (Volteron™)
- Diverse operations → unique scale provides access to options and opportunities

Securing resources:

- 1700MW renewable energy projects; Argentina (130MW), India (1GW; completion 1H'24) and Brazil (554MW; completion 2025)
- Three scrap recycling businesses acquired in UK/Europe with combined collection capacity of ~1.0Mt
- Accessing high quality DRI through acquisition of Texas HBI and organic investments (Canada DRI pellet conversion project, Serra Azul pellet feed)

A strong market presence:

- XCarb® products gaining an established market presence
- Our range of low-carbon emissions solutions is being adopted by customers across many end use segments. Most recent examples include
  - Vestas: XCarb® recycled and renewably produced heavy plate steel to an offshore wind farm, Poland
  - Schneider Electric: XCarb® recycled and renewably produced steel for its electrical cabinets and enclosures

Decarbonization projects progressing:

- **DRI/ EAF projects** across Europe and Canada progressing through FEED:
  - Contract signed with industrial engineering company for the new EAF in Gijon (Spain);
  - Letter of Intent signed with EDF for long-term supply of low-carbon electricity to support our project at Dunkirk (France); subject to final approvals of DRI/EAF projects
- **Carbon Capture and Usage, Ghent:** 1st industrial production of ethanol and bio-coal (from waste-wood) successfully used in the blast furnace

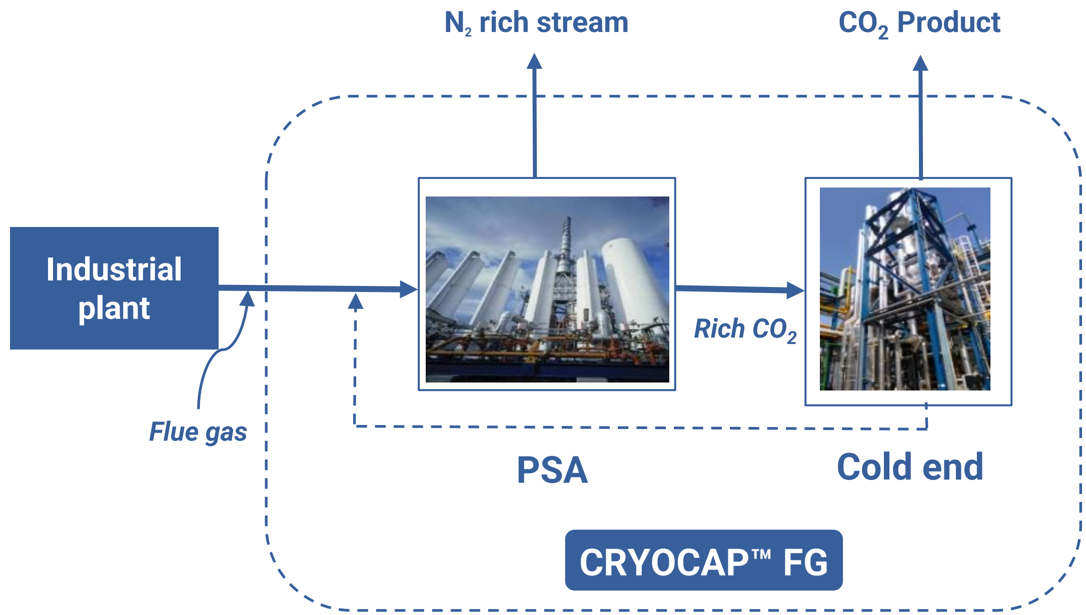
A capital efficient strategy focussed on cost position, ensuring long-term competitiveness and an acceptable return on the capital to be invested

Background on Capture Technology

Cryocap^{TM} Technology

Cryocap™ FG: CO_2 Capture from Flue Gas (~15% to 40% dry CO_2)

- Suitable for a large range Flue Gas types (Cement, Lime, SMR , …)
- PSA as a preconcentration brick
- HSE friendly (no chemicals and no flammables)
- Electricity powered (no steam needed)
- Compact & Flexible footprint: Compressors, PSA and Cold end can be located in 3 different plots
- NO_x Smart Management
- Gaseous or liquid CO_2
- CO_2 capture rate: 95%+



Project Management

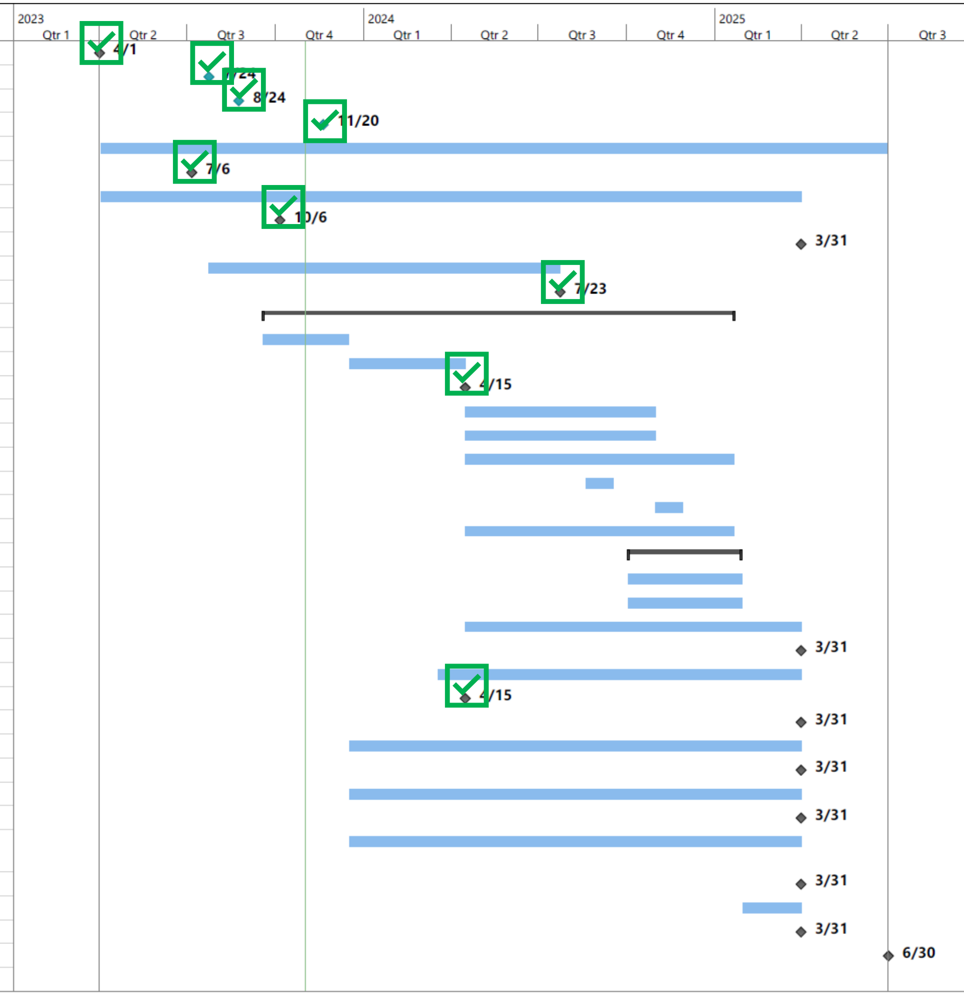
Milestones, Risks & Mitigation

Deliverables and Milestones

Task	Deliverable Title	Due Date
1.1	Project Management Plan	The first version has been delivered. Updates submitted according to latest schedule.
1.2	Technology Maturation Plan	The initial TMP has been delivered. Updates to the TMP shall be submitted, as needed, throughout the project period of performance. A final TMP is due 90 days prior to project completion.
1.3	Workforce Readiness Plan	The initial Plan is due at month 12 of the project based on the start date of the Period of Performance. - Revised to month 12 based on the Award Execution Date -. Subsequent updates to the Plan, as necessary, are due at 12-month intervals.
2.1	Design Basis	December 15, 2023
2.2	Initial Engineering Design Package	April 15, 2024
4.0	Business Case Analysis	Due 90 days prior to project completion.
5.0	Life Cycle Analysis	Due 90 days prior to project completion.
6.0	Technology Environmental Health and Safety Analysis	Due 90 days prior to project completion.
7.0	Environmental Justice Analysis	Due 90 days prior to project completion.
8.0	Economic Revitalization and Job Creation Analysis	Due 90 days prior to project completion.
9.0	Final Engineering Package	Due 90 days prior to project completion.

Project Schedule

Task Name	Start	Finish	Duration
Project Start	Sat 4/1/23	Sat 4/1/23	0 days
Award Executed	Mon 7/24/23	Mon 7/24/23	0 days
Internal KOM with team	Thu 8/24/23	Thu 8/24/23	0 days
KOM with DOE	Mon 11/20/23	Mon 11/20/23	0 days
1.0 Project Management and Planning	**Mon 4/3/23**	**Mon 6/30/25**	**586 days**
1.1 Project Management Plan First Issue	Thu 7/6/23	Thu 7/6/23	0 days
1.2 Technology Maturation Plan	Mon 4/3/23	Mon 3/31/25	521 days
Initial TMP Submission	Fri 10/6/23	Fri 10/6/23	0 days
Final TMP Submission	Mon 3/31/25	Mon 3/31/25	0 days
1.3 Workforce Readiness for Technology Development	Mon 7/24/23	Tue 7/23/24	262 days
Workforce Readiness Plan Submission	Tue 7/23/24	Tue 7/23/24	0 days
2.0 Front-End Engineering Design (FEED) Study	**Mon 9/18/23**	**Mon 1/20/25**	**351 days**
2.1 Design Basis	Mon 9/18/23	Fri 12/15/23	65 days
2.2 Preliminary Engineering	Mon 12/18/23	Mon 4/15/24	86 days
Preliminary Engineering Package Submission	Mon 4/15/24	Mon 4/15/24	0 days
2.3 Carbon Capture System Engineering Design Package	Tue 4/16/24	Wed 10/30/24	142 days
2.4 Balance of Plant Engineering Design Package	Tue 4/16/24	Wed 10/30/24	142 days
2.5 Water Impacts on Local Environment	Tue 4/16/24	Mon 1/20/25	200 days
2.6 HAZOP Review	Tue 8/20/24	Mon 9/16/24	20 days
2.7 Constructability Review	Thu 10/31/24	Wed 11/27/24	20 days
2.8 Permitting Considerations	Tue 4/16/24	Mon 1/20/25	200 days
3.0 Project Cost Assessment	**Thu 10/3/24**	**Tue 1/28/25**	**84 days**
3.1 ISBL Cost Estimates	Thu 10/3/24	Tue 1/28/25	84 days
3.2 OSBL Cost Estimates	Thu 10/3/24	Tue 1/28/25	84 days
4.0 Business Case Analysis	**Tue 4/16/24**	**Mon 3/31/25**	**250 days**
BCA Submission	Mon 3/31/25	Mon 3/31/25	0 days
5.0 Life Cycle Analysis (LCA)	**Tue 3/19/24**	**Mon 3/31/25**	**270 days**
Initial LCA Submission	Mon 4/15/24	Mon 4/15/24	0 days
Final LCA Submission	Mon 3/31/25	Mon 3/31/25	0 days
6.0 Technology EH&S Risk Analysis	**Mon 12/18/23**	**Mon 3/31/25**	**336 days**
Final EH&S Risk Assessment Submission	Mon 3/31/25	Mon 3/31/25	0 days
7.0 Environmental Justice Analysis	**Mon 12/18/23**	**Mon 3/31/25**	**336 days**
Final EJ Analysis Submission	Mon 3/31/25	Mon 3/31/25	0 days
8.0 Economic Revitalization and Job Creation Outcomes Analysis	**Mon 12/18/23**	**Mon 3/31/25**	**336 days**
Final Revitalization and Job Analysis Submission	Mon 3/31/25	Mon 3/31/25	0 days
9.0 Final FEED Study Package & Final report	**Thu 1/30/25**	**Mon 3/31/25**	**43 days**
Final Engineering Design Package Submission	Mon 3/31/25	Mon 3/31/25	0 days
Performance Period Completion	Mon 6/30/25	Mon 6/30/25	0 days



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Design Basis

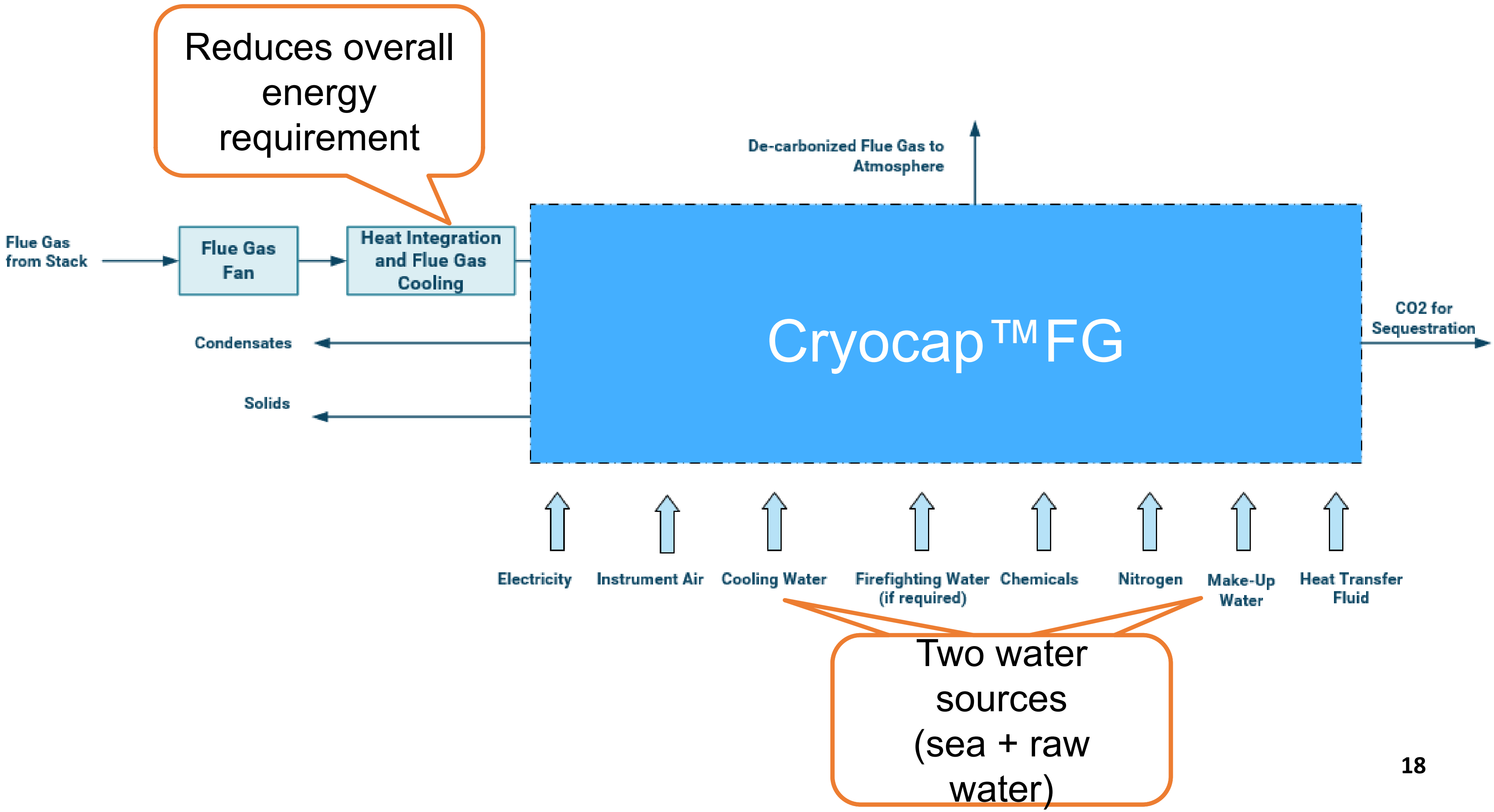
Carbon Capture Plant Feed Conditions

			Rated [10]	Nominal [4]	Turndown [4][6][10]
HBI Production Rate		tonnes/hr	281.6	256	170
Flue Gas Temperature [1] [2]		°F (°C)	650 (343)	600 (316)	550 (288)
Flue Gas Pressure [1] [2]		psia (bara)	14.696 (1.01325)	14.696 (1.01325)	14.696 (1.01325)
Flue Gas Total Mole flow (wet) [2] [3][9]		kmol/hr	21,695	19,722	13,097
Flue Gas Total Mole flow (wet) [2] [3] [9]		Nm3/h [7]	486,259	442,054	293,551
Flue Gas Total Mole flow (wet) [2] [3] [9]		SCFM [8]	302,500	275,000	182,617
Composition [2][3][5]					
Carbon Dioxide	CO_2	mol% (dry)	18.98	18.98	18.98
Nitrogen	N_2	mol% (dry)	79.02	79.02	79.02
Oxygen	O_2	mol% (dry)	1.91	1.91	1.91
Argon	Ar	mol% (dry)	0.09	0.09	0.09
Water	H_2O	mol%	21.83	21.83	21.83

Carbon Capture Plant Product Specifications

- Delivery Pressure: 2100-2200 psig (144.79 – 151.68 barg)
- CO_2 composition: >95 vol% (dry basis)

Block Flow Diagram



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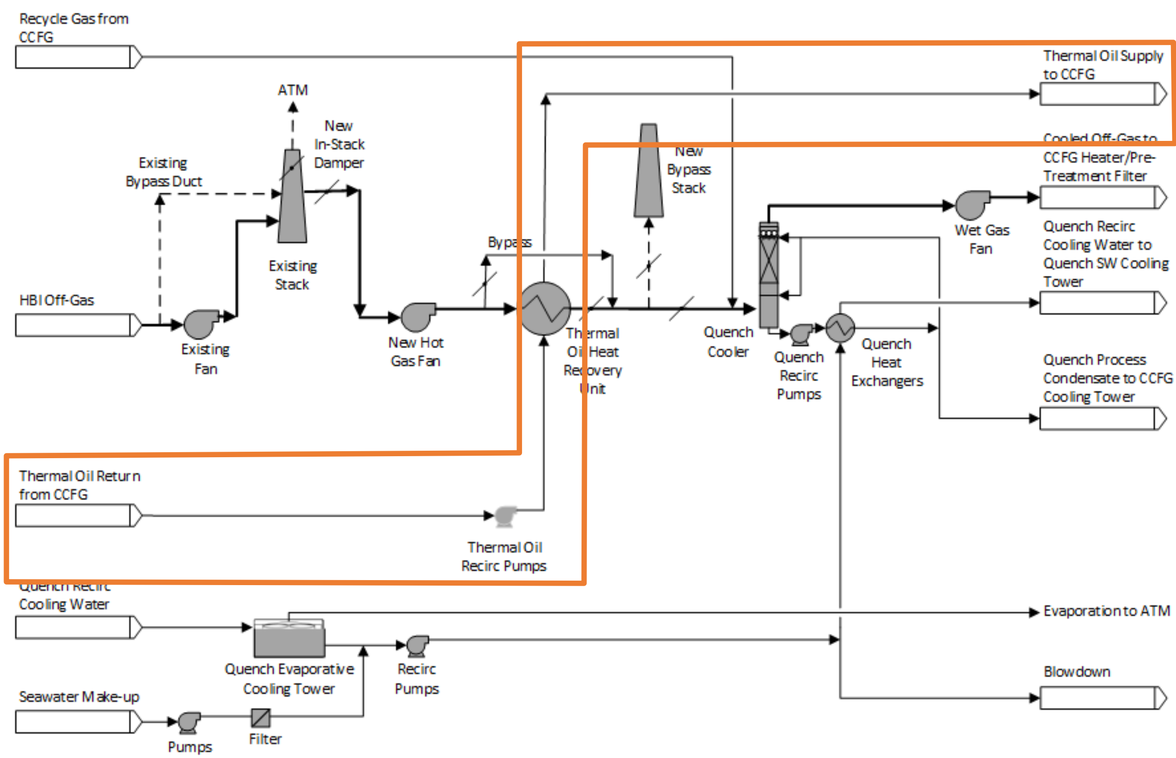
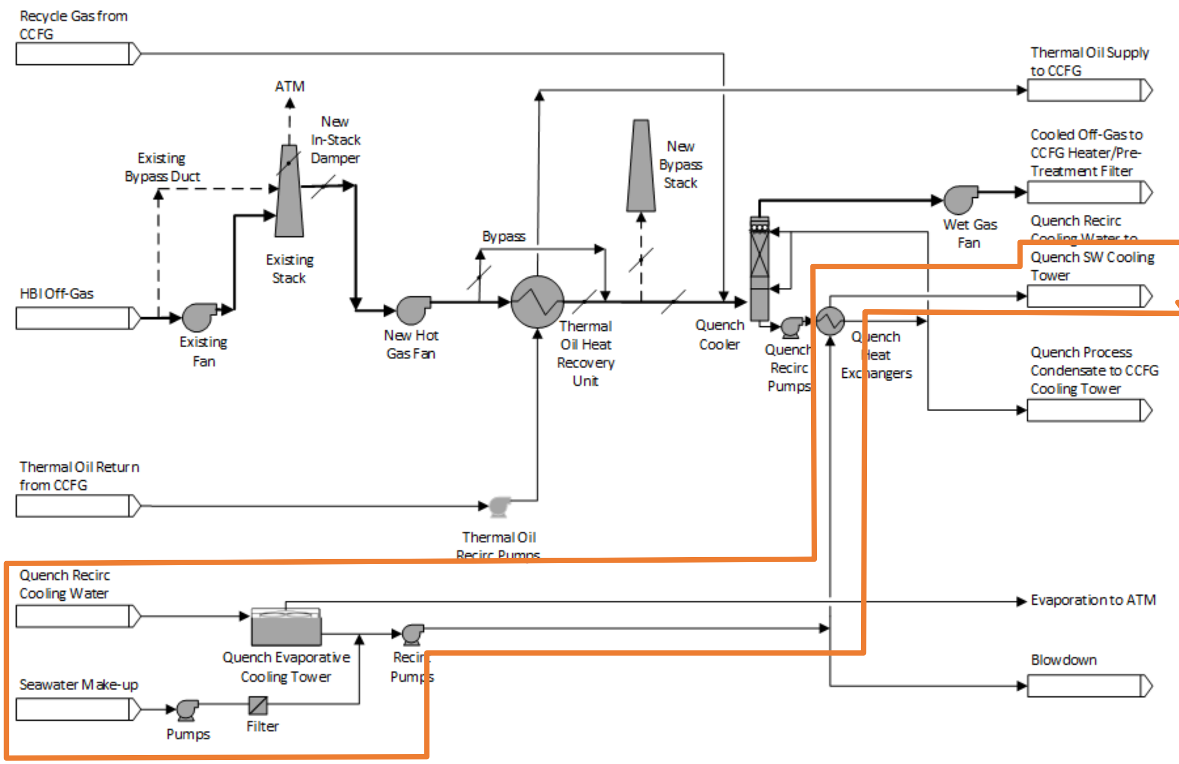
Optimization Studies: Heat Recovery



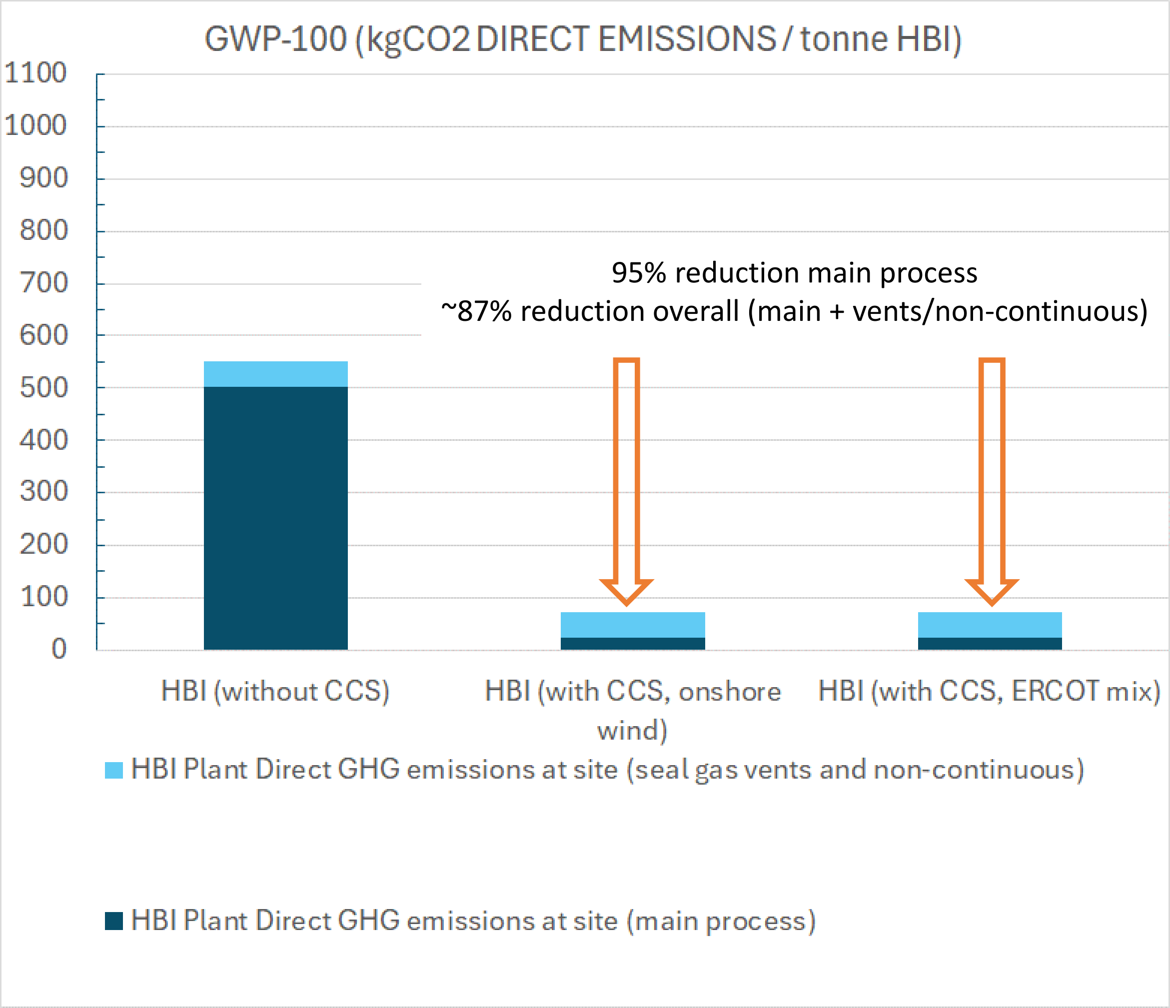
- Several options for heat recovery were investigated.
- Waste Heat Recovery with thermal oil selected as the most efficient solution. Hot oil is then used for ISBL process heating.

Optimization Studies: Water Sources



- Fresh water in demand in the region.
- Water sources split to reduce strain on fresh water and benefit from process efficiencies derived from lower source temperatures.
- Seawater used for quench cooling water make-up.
- Raw water from San Pat industrial supply to be used as make-up for ISBL cooling water (evap. cooling).

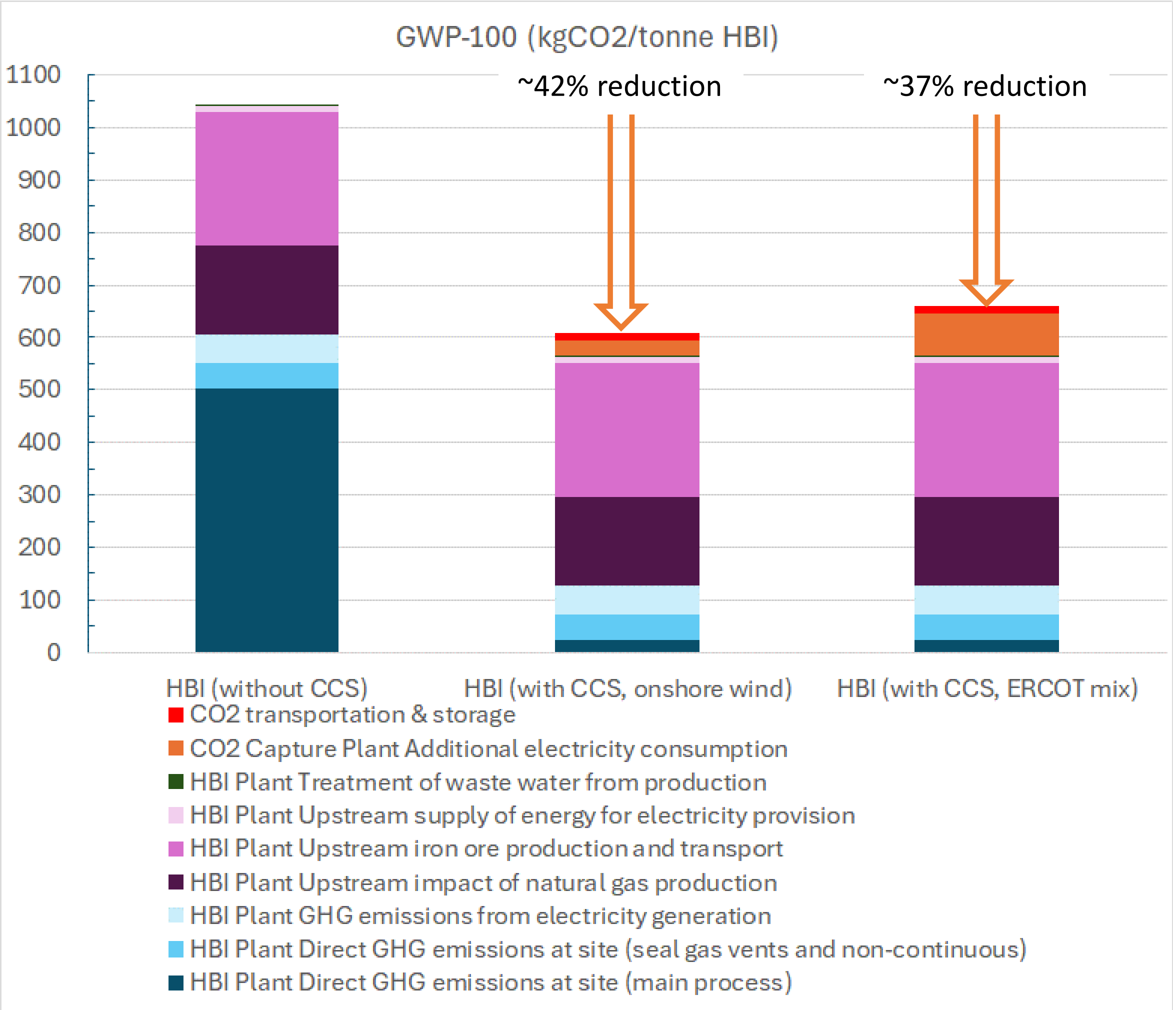
Preliminary Life Cycle Analysis



Scope: cradle to gate
Functional unit: 1 tonne iron
Method: TRACI 2.1 (NETL)
Electricity:
    Case 1: Onshore wind
    Case 2: ERCOT mix
Baseline:

- GHG emissions at site (main process)
- Upstream impacts from GaBi-DB 2021.1 Carbon Footprint (EN 15804+A2 characterization factors)

Preliminary Life Cycle Analysis



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Acknowledgements

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Name	Organization
Krista Hill, Jodi Collins	National Energy Technology Laboratory / US Department of Energy


Questions
Answers