Capabilities Development at The University of Texas at El Paso for **Hydrogen Generation Research and Education**

Award No: DE - FE0032201

PI: Nawshad Arslan Islam, Ph.D.
Research Associate
Aerospace Center, University of Texas at El Paso

Co PI: Ahsan Choudhuri, Ph.D.
Associate Vice President
Aerospace Center, University of Texas at El Paso

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Assistant Professor
Aerospace and Mechanical Engineering Department
University of Texas at El Paso

2023 FECM/NETL Spring R&D Project Review Meeting, Pittsburg, PA
Fossil Energy and Carbon Management Program
National Energy Technology Laboratory
Department of Energy
18th April 2023

UTEP AEROSPACE CENTER

OUTLINE

- Project Information
- Project Objectives
- Project Team
- Project Progress
- Publications
- Timeline
- Milestone Log
- Budget
- Success Criteria
- Deliverables

PROJECT INFORMATION

Project Title:	Capabilities Development at The University of Texas at El Paso for Hydrogen Generation Research and Education
Award No:	DE – FE0032201
Investigators:	Dr. Nawshad Arslan Islam, Email: mislam12@utep.edu, Phone: 915-747-6199
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UTEP Business Contact:	Raul Chavez, Email: rchavez13@utep.edu, Phone: 915-747-5680
Period of Performance:	01/01/2023 – 12/31/2023
Project Amount:	$200,000
UTEP Research Centers:	Aerospace Center (formerly NASA MIRO Center for Space Exploration and Technology Research)

PROJECT OBJECTIVES

The overarching goal of this project is to assess the R&D capability of the Aerospace Center at UTEP to develop a sustainable Hydrogen research facility

Objective 1: Analysis of the current state-of-the-art MSW gasification systems and capability assessment of the UTEP Aerospace Center

- Task 1.1: The gasification system: state-of-the-art review and technology gap analysis
- Task 1.2: Concept Development
- Task 1.3: UTEP Aerospace Center's Capability Assessment

Objective 2: Planning of hydrogen production research facility and future hydrogen research capabilities

- Task 2.1: Mapping of Hydrogen Research
- Task 2.2: Determination of Required Equipment, Cost Analysis and Procurement Plan
- Task 2.3: Developing Partnership and Outreach Efforts

Objective 3: Student training and education in hydrogen research and gasifier

- Task 3.1: Student Training in the Gasifier Systems
- Task 3.2: Student Training in Gasifier Process Simulation
- Task 3.3: Hydrogen power generation and energy systems course development

PROJECT TEAM

PI & Co-PIs

Nawshad Arslan Islam, Ph.D.
Principal Investigator
Research Associate,
Aerospace Center, UTEP

Ahsan Choudhuri, Ph.D.
Co – Principal Investigator
Associate Vice President,
Aerospace Center, UTEP

Joel Quintana, Ph.D.
Co – Principal Investigator
Assistant Professor, Aerospace &
Mechanical Engineering, UTEP

Aerospace Center Staff Support

Luz Bugarin
Director of Operations

Gloria Salas
Director of Business Operations

Mehrin Chowdhury, Ph.D.
Student Success Manager

Ariful Ahsan, Ph.D.
Project Manager

Student Team

Sumit Chanda
Ph.D. Research Assistant

Anika Farhat Tasnim
MS/Ph.D. Research Assistant

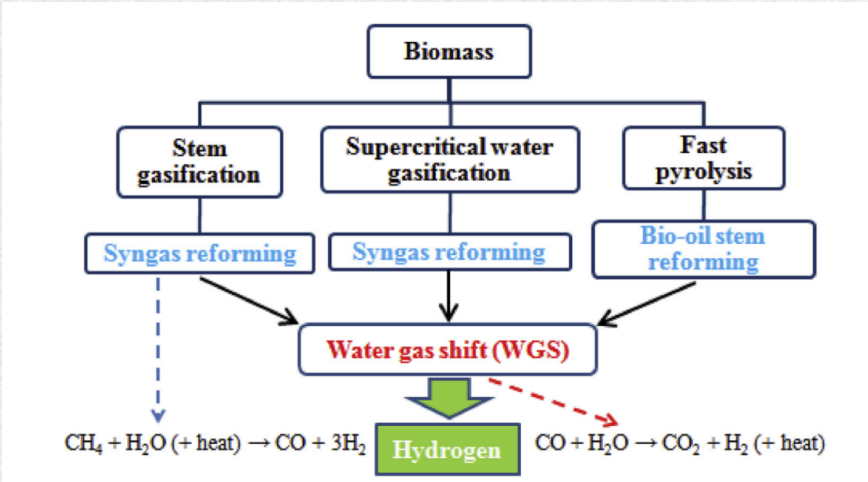
Daniel Reyes
Undergraduate Research Assistant

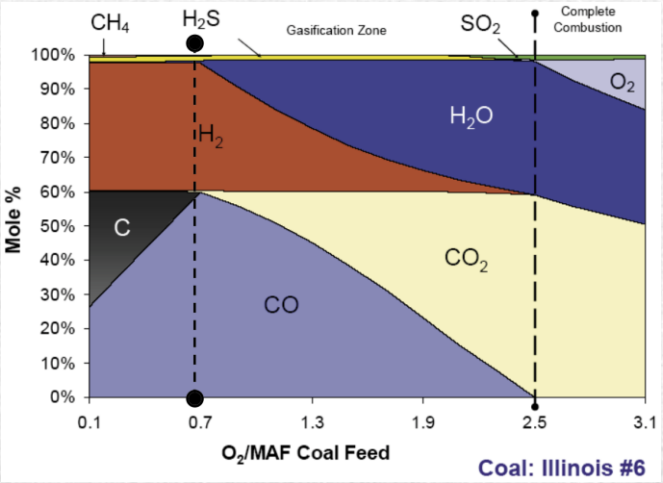
Luis Alvarado Mendoza
Undergraduate Research Assistant

PROJECT PROGRESS

Task 1.1: State of the Art Gasification System Review

Nos.	Reaction name	Reaction chemistry	ΔH (MJ/kmol)
R1	Boudouard	$C + CO_2 \leftrightarrow 2CO$	172.5
R2	Water gas	$C + H_2O \leftrightarrow CO + H_2$	131.3
R3	Dry reforming	$CH_4 + CO_2 \leftrightarrow 2CO + 2H_2$	247.0
R4	Water gas shift	$CO + H_2O \leftrightarrow H_2 + CO_2$	−41.1
R5	CO methanation	$CO + 3H_2 \leftrightarrow CH_4 + H_2O$	−205.8
R6	CO_2 methanation	$CO_2 + 4H_2 \leftrightarrow CH_4 + 2H_2O$	−165.0
R7	Combustion	$C + \frac{1}{2}O_2 \rightarrow CO$	−110.5





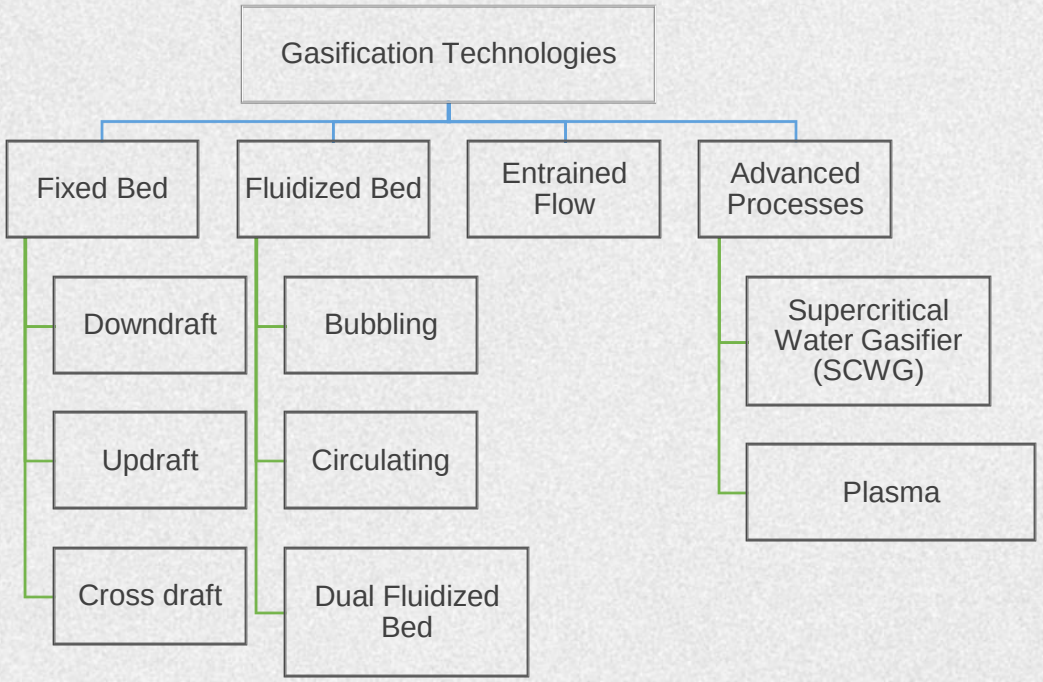
A complex process in which combustible materials are partially oxidized or partially combusted to produce Syngas (CO, CH_4, H_2)

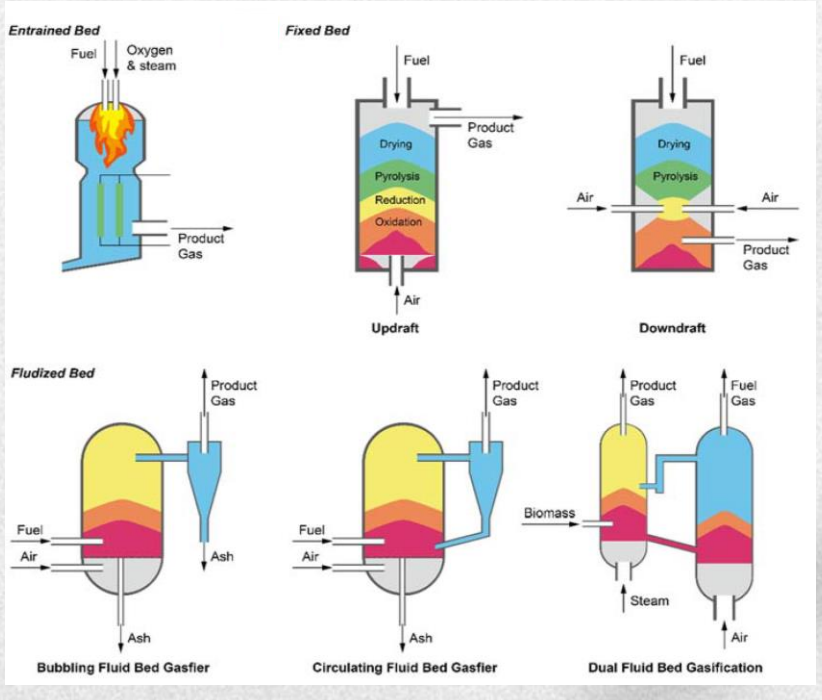
The process operates in an oxygen-lean environment
Gasification feeds - Coal, Biomass, Plastic, Municipal Solid Waste (MSW), Sludge
Gasifying medium - Air, Oxygen, CO_2, Steam

https://netl.doe.gov/sites/default/files/netl-file/1-2-1.pdf
Cao, L., Iris, K.M., Xiong, X., Tsang, D.C., Zhang, S., Clark, J.H., Hu, C., Ng, Y.H., Shang, J. and Ok, Y.S., 2020. Biorenewable hydrogen production through biomass gasification: A review and future prospects. Environmental research, 186, p.109547.

PROJECT PROGRESS

Task 1.1: State of the Art Gasification System Review

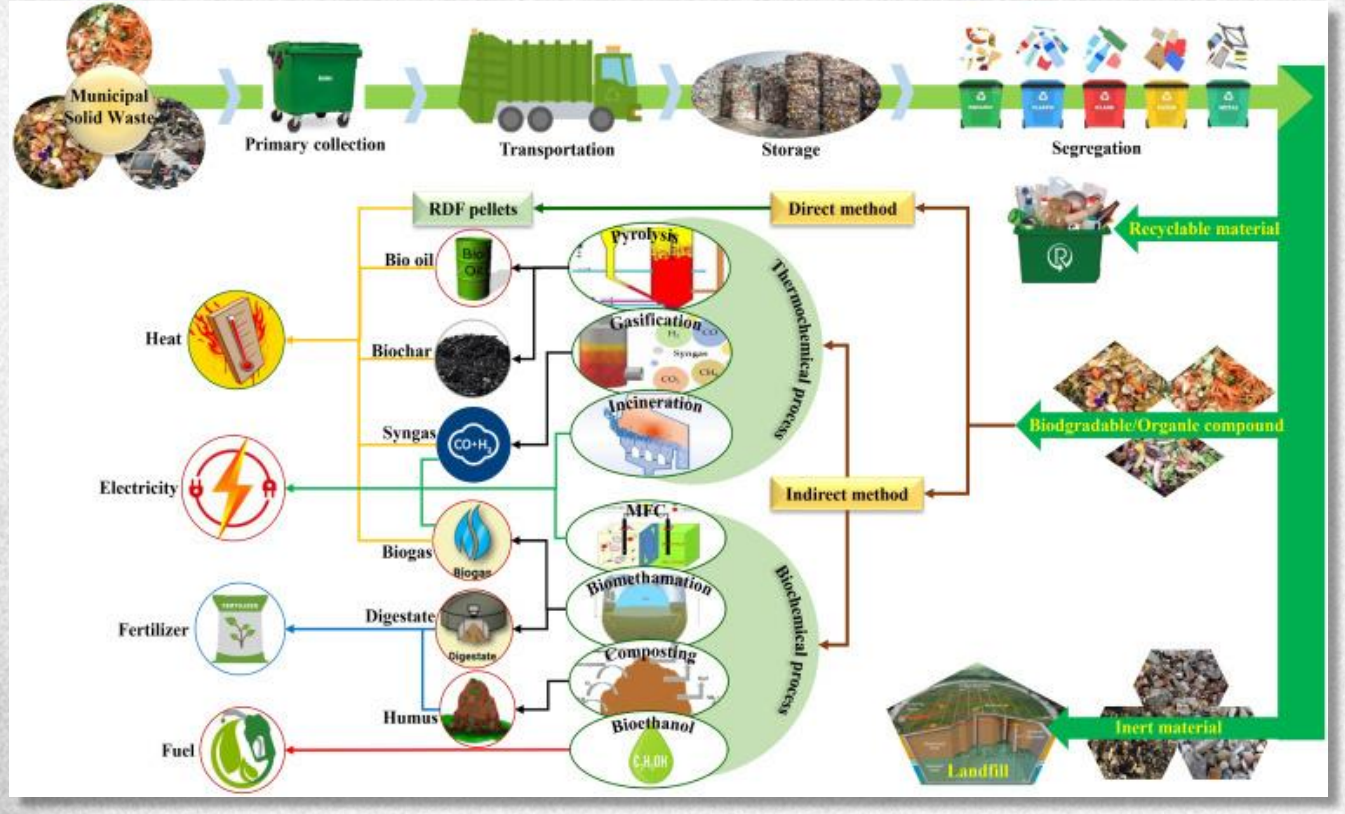




Lian, Z., Wang, Y., Zhang, X., Yusuf, A., Famiyeh, L., Murindababisha, D., Jin, H., Liu, Y., He, J., Wang, Y. and Yang, G., 2021. Hydrogen production by fluidized bed reactors: a quantitative perspective using the supervised machine learning approach. *J*, *4*(3), pp.266-287.

PROJECT PROGRESS

Task 1.1: State of the Art Gasification System Review



Feedstocks

Biomass and MSW can be a potential options to produce H_2 from sustainable resources

Advantages of using sustainable resources -

- Biomass is proven to carbon negative
- MSW gasification recovers waste energy
- Better option compared to landfill or incineration
- Co-gasification of Biomass and MSW can potentially be carbon neutral
- Can improve the Hydrogen production cost

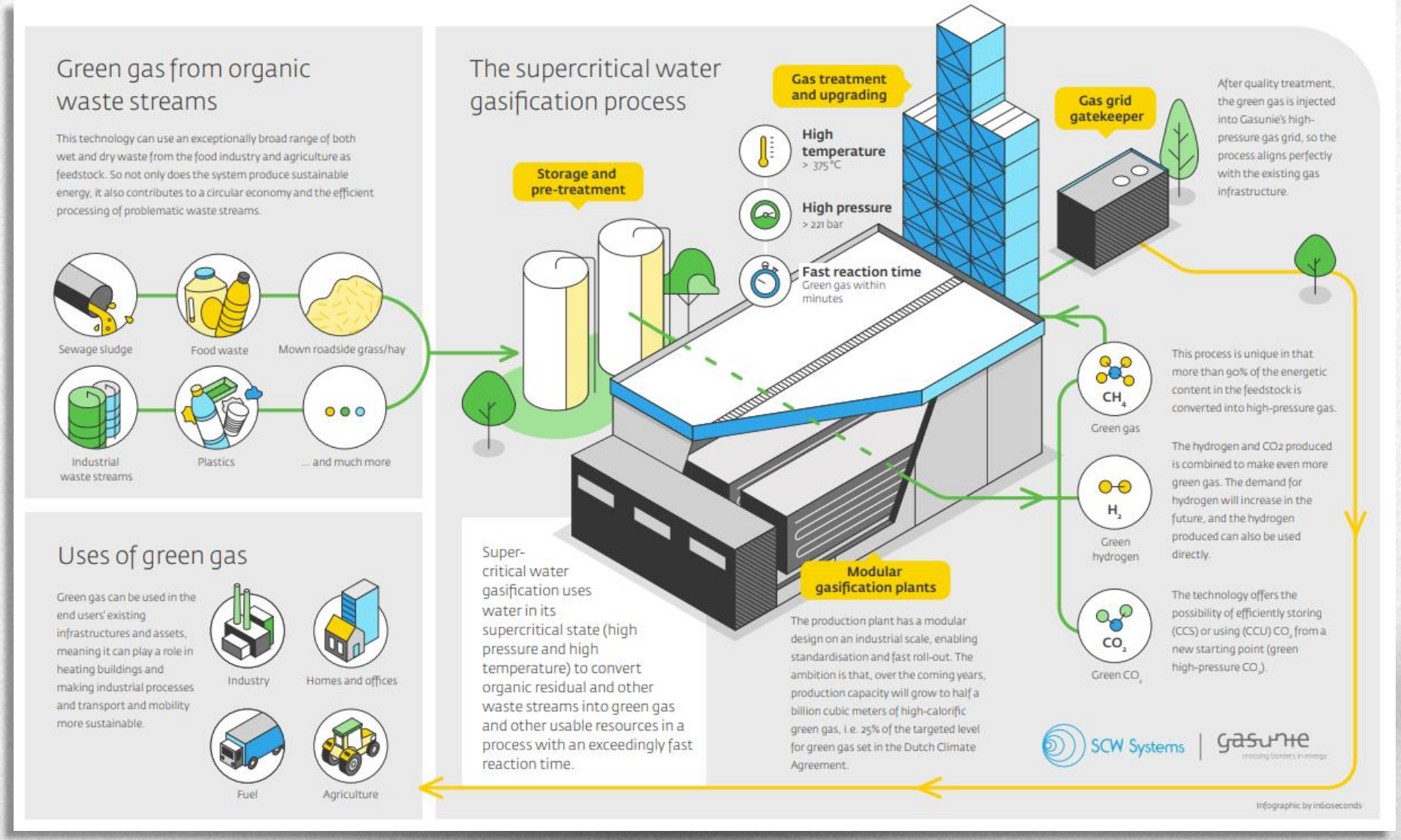
Application

- Fuel-Cell H_2
- Sustainable Aviation fuel
- Transportation fuel (Marine, Rail, off-road, agricultural, vehicle)
- Powerplant
- High-value products

Hoang, A.T., Varbanov, P.S., Nižetić, S., Sirohi, R., Pandey, A., Luque, R. and Ng, K.H., 2022. Perspective review on Municipal Solid Waste-to-energy route: Characteristics, management strategy, and role in circular economy. *Journal of Cleaner Production*, p.131897.

PROJECT PROGRESS

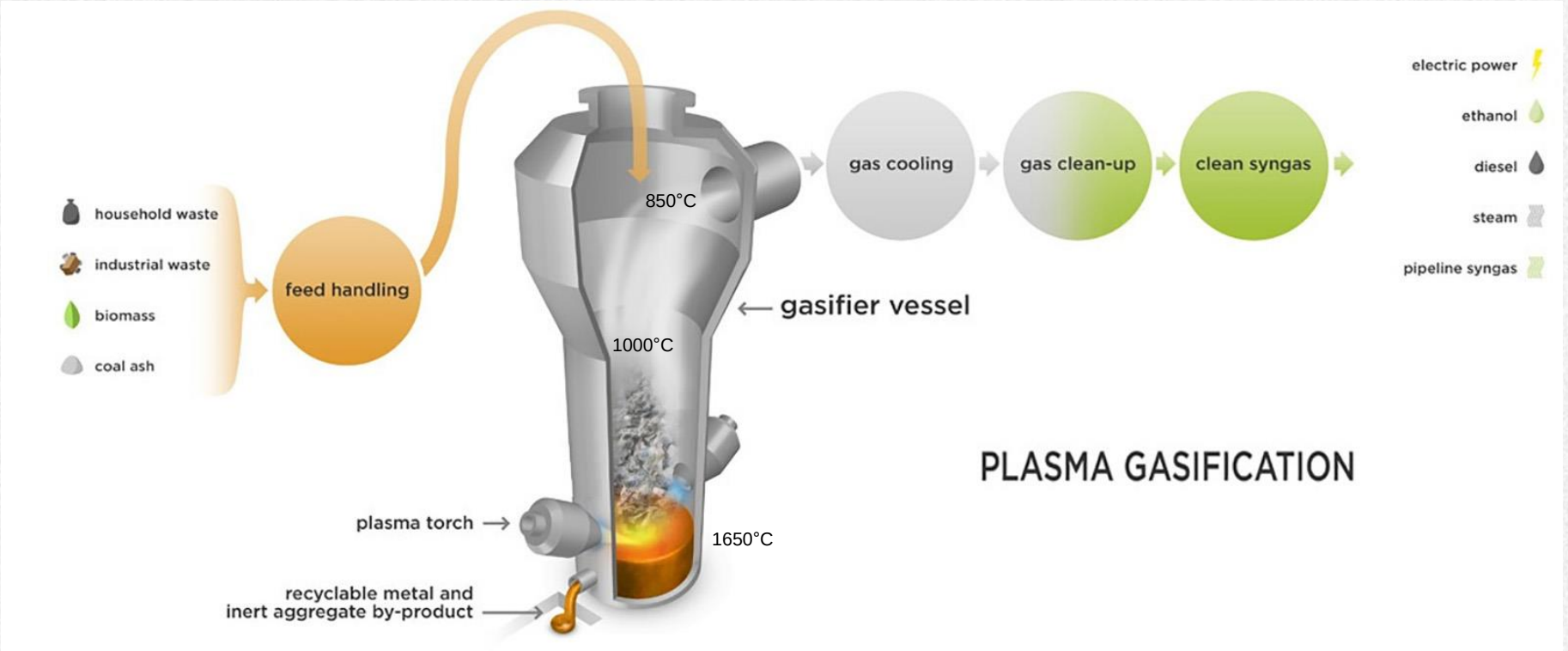
Task 1.1: State of the Art Gasification System Review



https://www.gasunie.nl/en/expertise/green-gas/supercritical-water-gasification

PROJECT PROGRESS

Task 1.1: State of the Art Gasification System Review



https://www.ce.eco/en/products/plasma/how-it-works

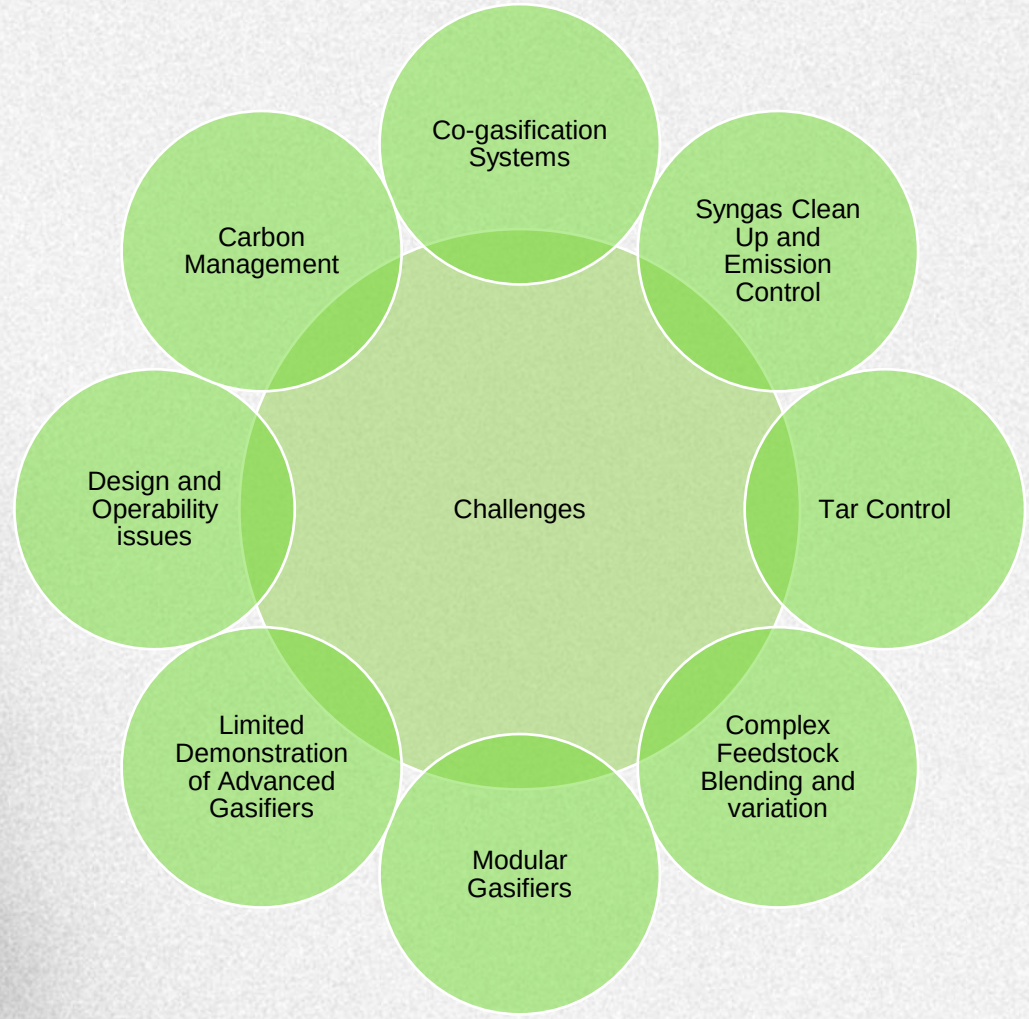
https://netl.doe.gov/research/Coal/energy-systems/gasification/gasifipedia/westinghouse

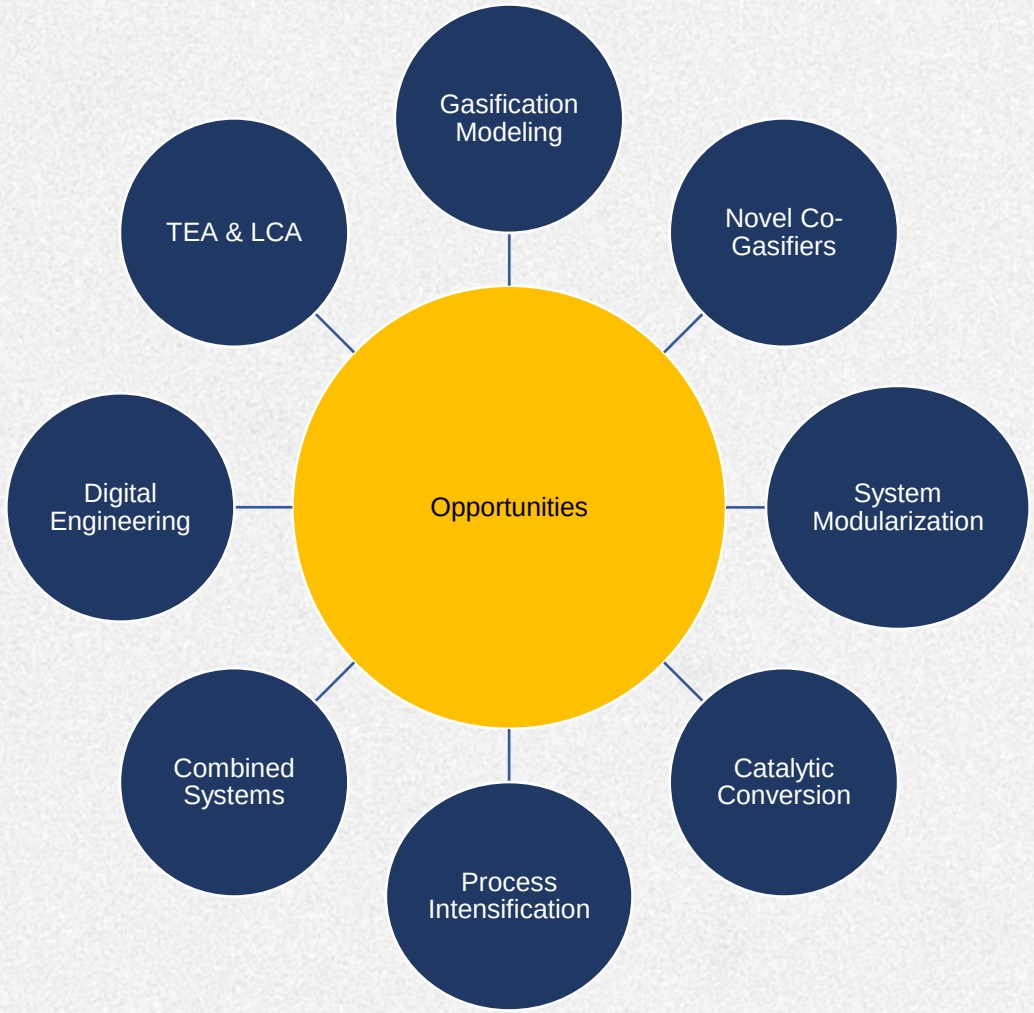
https://globalsyngas.org/syngas-technology/syngas-production/waste-to-energy-gasification/plasma-gasification/

https://www.cahill-energy.com/plasma-gasification/

PROJECT PROGRESS

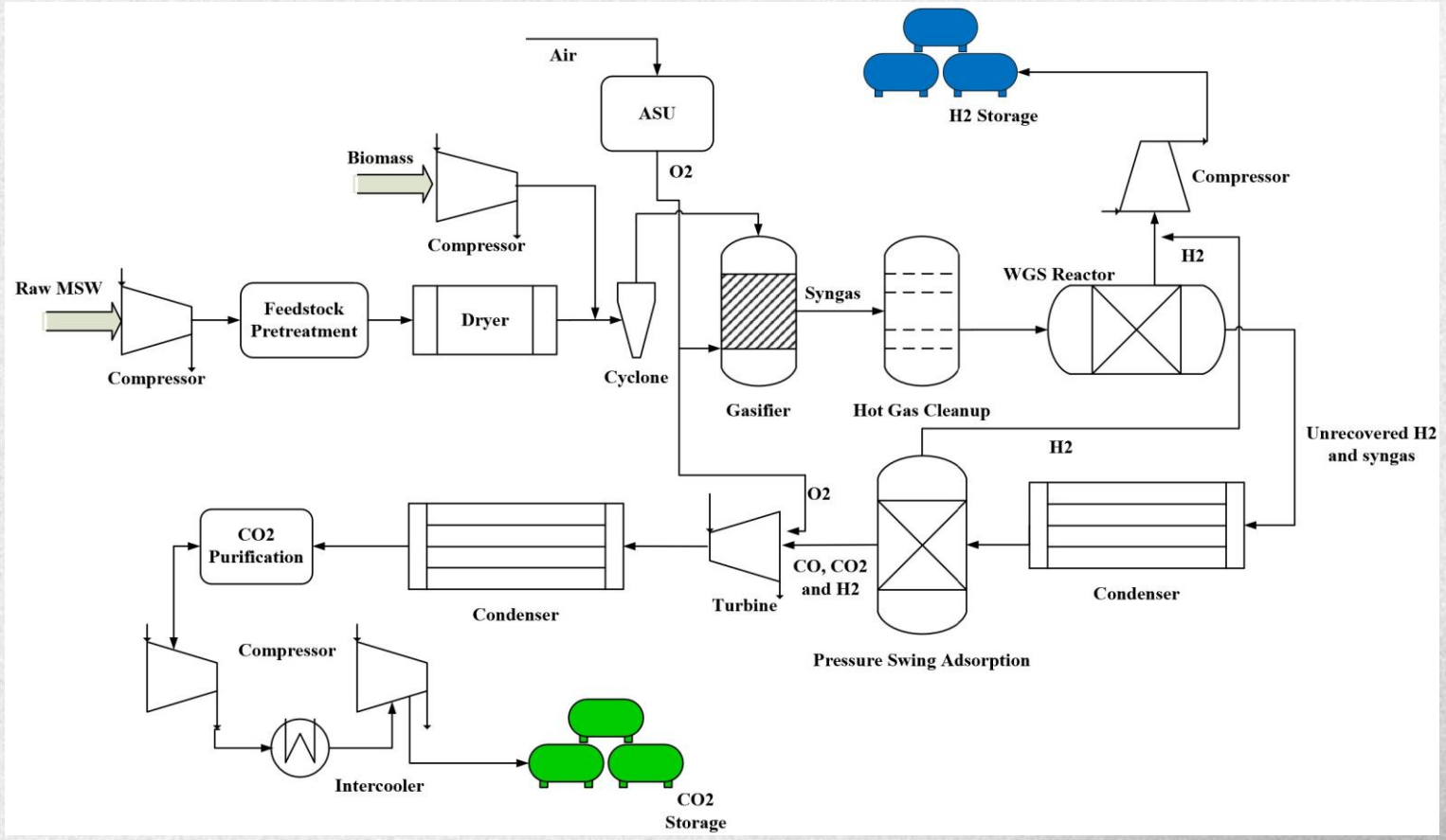
Task 1.1: State of the Art Gasification System Review

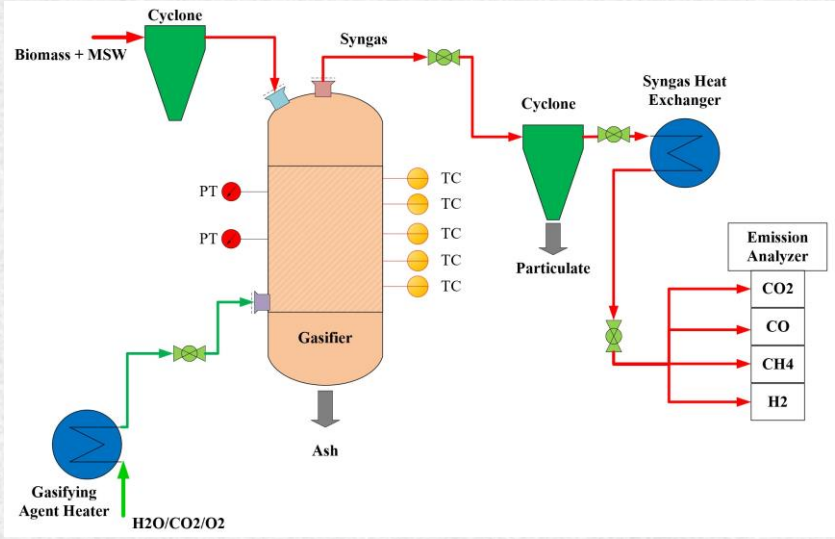


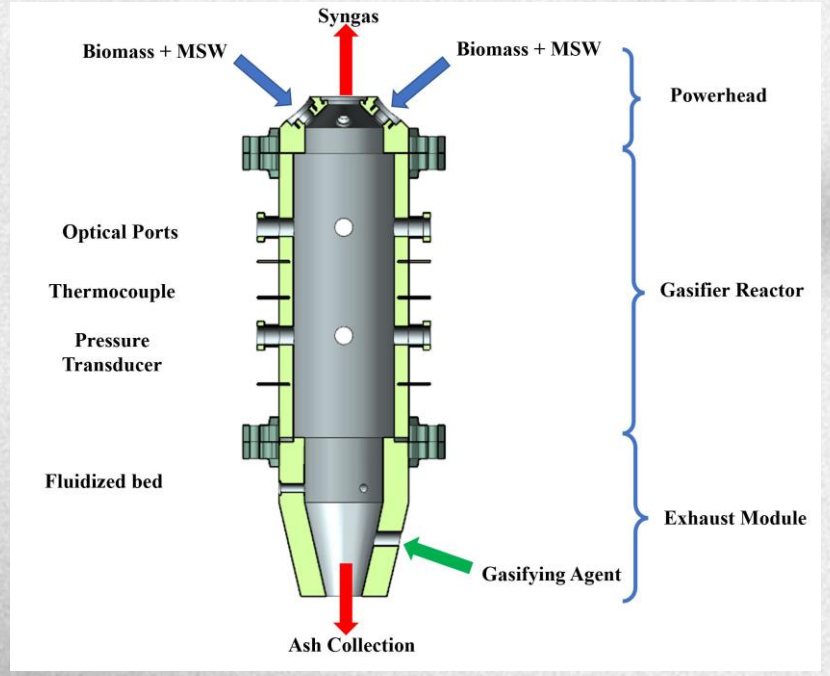


Task 1.2: Concept Development

High Pressure (≥ 10 bar) Co-Gasification of MSW and Biomass







University of Texas at El Paso (UTEP)

America's Leading Hispanic Serving University

- A R1 university with 24000+ students in 170 Undergraduate and graduate level over 10 colleges
- 84% Hispanic Ethnicity
- Over $115M in research expenditure

PROJECT PROGRESS

Task 1.3: Capability Assessment of UTEP Aerospace Center

AEROSPACE CENTER

Center of Excellence in Aerospace and Defense Systems Research

Aerospace Center has an expansive strategic partnership with NASA and Aerospace and Defense Industries to educate a diverse future aerospace and defense workforce.

PROJECT PROGRESS

Task 1.3: Capability Assessment of UTEP Aerospace Center

UTEP Aerospace Center-cSETR
650 Students/yr.
300,000 sq. ft. Laboratories
8,000 acres Test Facilities

2025

UTEP Aerospace Center-cSETR
120 Students/yr.
35,000 sq. ft. Laboratories
8,000 acres Test Facilities

2020

MIRO cSETR
70 Students/yr.
15,000 sq. ft. Laboratories

2015

URC cSETR
30 Students/yr.
4000 sq. ft.

2009

A Giant Leap Forward

Sustainability

UT System Aerospace Capacity Development
$70 million
2020

Industry and UTEP Aerospace Capacity Development
$4.8 million
2015

UTEP Aerospace Laboratory Improvement
$1.5 million
2009

Aerospace Center/cSETR

Space Research Division supports NASA's Artemis program and Moon to Mars vision by focusing on strategic capabilities in propulsion and robotic lander, lunar surface exploration, and small spacecraft technologies.

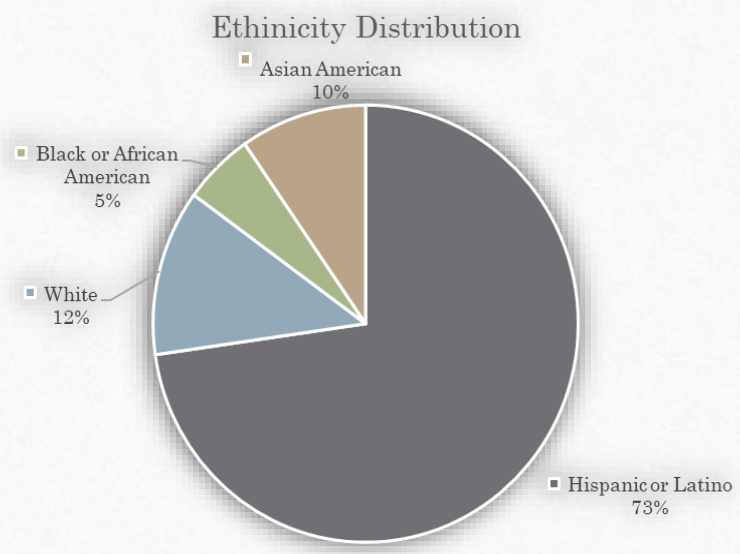
Aeronautics and Defense Division supports the research and development of hypersonic, missile, and unmanned aerial systems technologies. Aeronautics and Defense Division aspires to support the US Space Force's Space Superiority domain through innovation in Space Domain Awareness and Space Access & Sustainment.

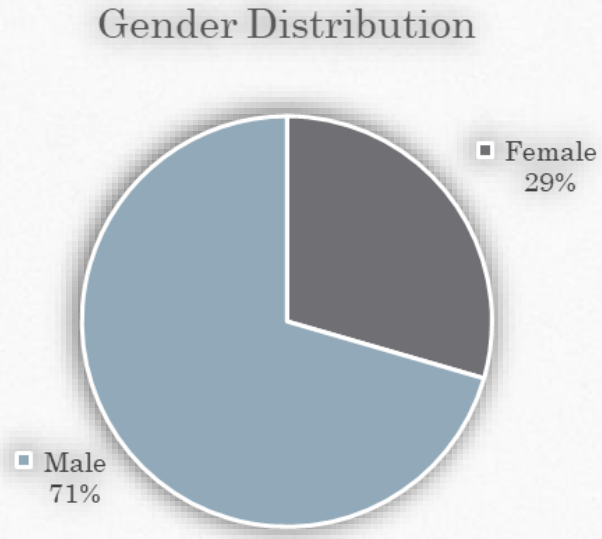
Energy and Sustainability Engineering Division provides capabilities in sub-pilot scale to commercial scale fossil, nuclear, and renewable energy technology development; prototype to commercial product demonstration as well as test and evaluation.

Economic Development and Workforce Excellence Division supports the development of an advanced and technology-based industrial economy for El Paso and West Texas and an integrated workforce with all skill spectrum for small and medium high-tech business expansion.

PROJECT PROGRESS

Task 1.3: Capability Assessment of UTEP Aerospace Center





Total	UG	MS	PhD
190	120	34	36

In the 2019-2020 academic year alone, Lockheed Martin Corporation hired 101 of our students, 66 full time and 35 intern/co-op.

AEROSPACE CENTER AT A GLANCE

Facilities

University Campus Facilities | 17,915 sq. ft.

Goddard's Combustion & Propulsion Research Facility
  Includes ultra-high velocity projectile resistance bunker
Challenger-Columbia Structures & Materials Research Facility
Digital Engineering Facility
Generative Design Laboratory
Sensitive Compartmented Information Facility (SCIF)

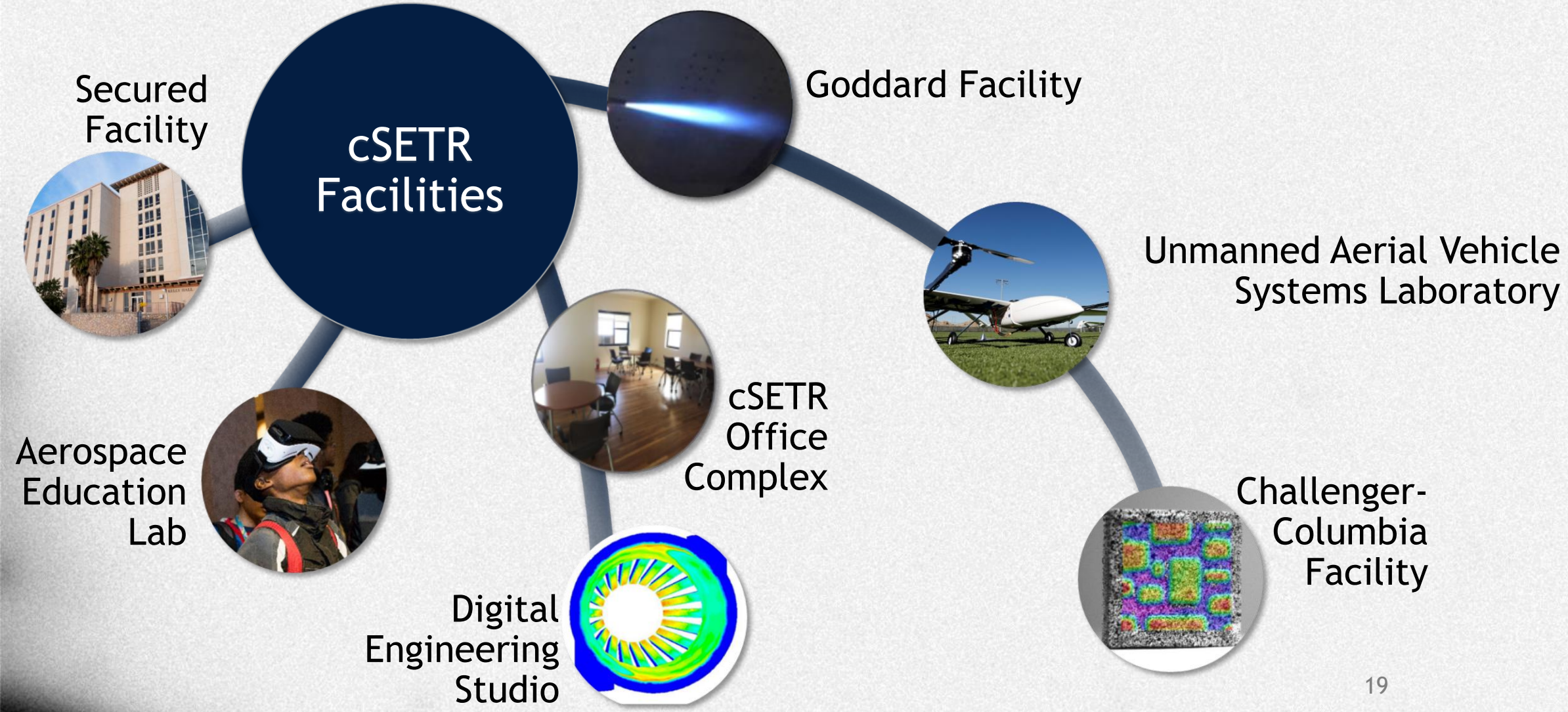
Off Campus Facilities

Technology Research & Innovation Acceleration Park | Fabens, TX
- General Aviation Airport | 4200 ft. & 2300 ft. Runways | 400 acres
- HQ Site | Propulsion and Energy Systems Integration Facility | 10,200 sq. ft.
- Alpha Site | Propulsion and Large-Scale Testing Facility | 18 Acres + 600 Acres
- Aeronautics Research & Learning Facility (Planned) | 10,000 sq. ft.

Bravo Site: Tornillo Unmanned Aerial System Flight Test Range | Tornillo, TX | 600 acres
- 400 ft. Runways | Test Support Facility
- LSTAR Radar | 100 KW Power Trailer

Spacecraft Design and Engineering Facility | Francis St, El Paso, TX | 8,840 sq. ft.
- Including | Satellite Ground Station | 2.4 m S-b& antenna | 436 MHz UHF antenna
- (9) Training Rooms, (10) Office Spaces, & Student Collaborative Space

Current On-Campus Facilities



Off-Campus Facilities

tRIAc - Alpha Site

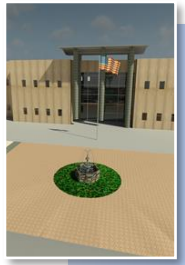
- Research & Development
- Control Center
- Test Cells
- Vertical Test Stand

Fabens, TX

tRIAc - HQ Site

- Design studio & Manufacturing Workshop
- Fabrication and Integration Shop
- Collaboration Common: Graduate, Undergraduate, & K-12

Fabens, TX



Tornillo Unmanned Aerial System Flight Test Range

- 20-25 acres facility + Flight Test Range (600 acres)
- 400-ft Runway
- Test Support Facility (planned)

Fabens, TX

tRIAc - Aeronautics Research and Learning Facility (Planned)

- Flight Wind-Tunnel Research and Education Complex
- Subsonic Wind Tunnel
- Water Tunnel Supersonic Tunnel

Fabens, TX

Fabens General Aviation Airport

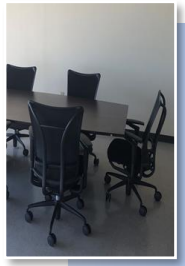
- *Partner Facility*
  - Managed by El Paso County
- 4,200 ft. & 2,300 ft. Runways
- 400 acres

Fabens, TX

Francis Facility

- Spacecraft Development Facility
- Satellite Ground Station (underdevelopment)
  - 2.4 m S-band antenna | 436 MHz UHF antenna

El Paso, TX



Horizon City Aerospace and Defense Accelerator

- *Partner Facility*
  - Horizon City Economic Development Corporation
- Small Business Incubator

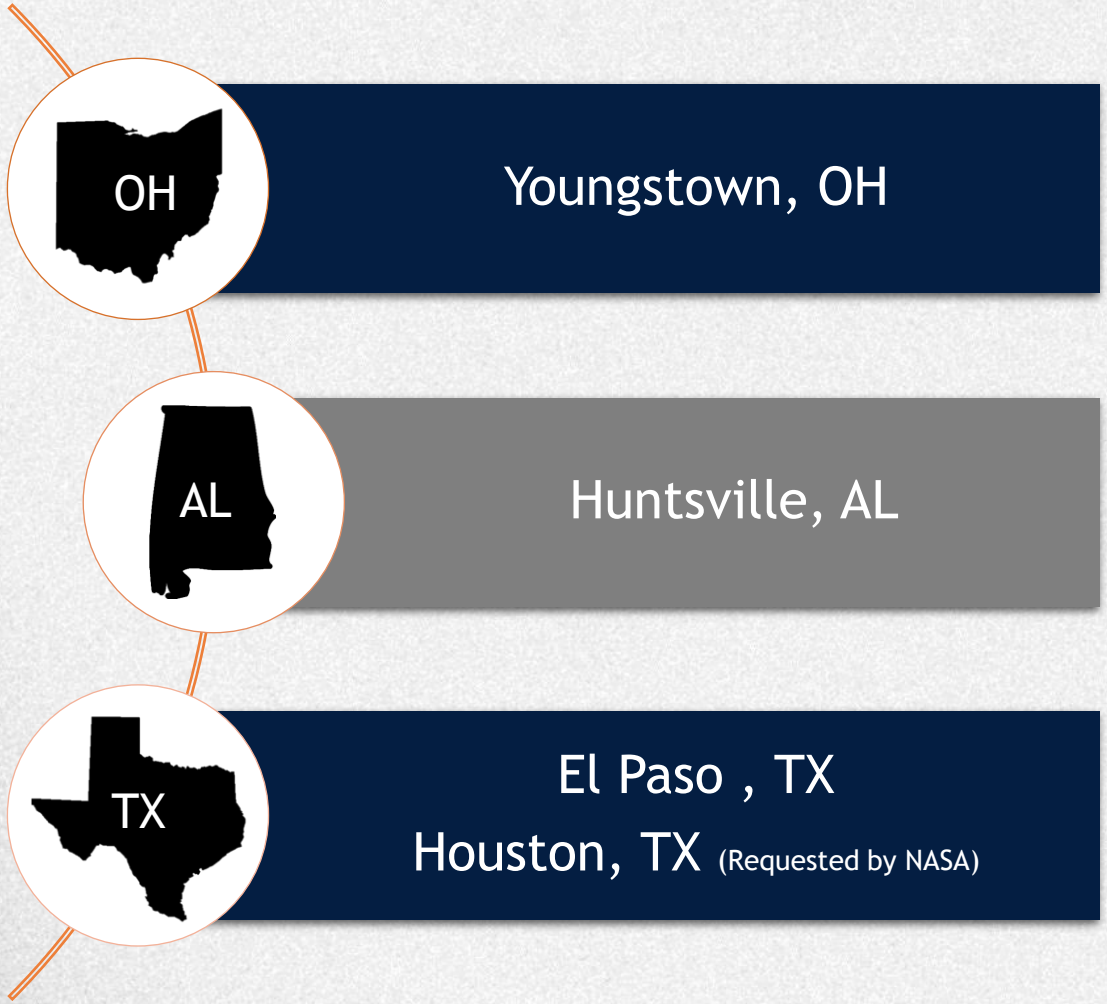
Horizon, TX

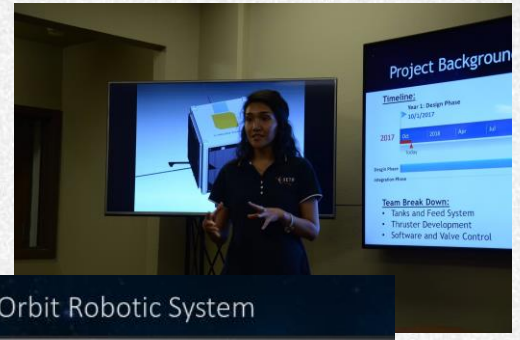
TMD Defense and Space

- *Partner Facility*
- Administrative Area & 21,000 sf warehouse, Hazardous Material Assembly Area with (10) Missile Assembly Cells & (7) Storage Magazines & Firefighting Support Building

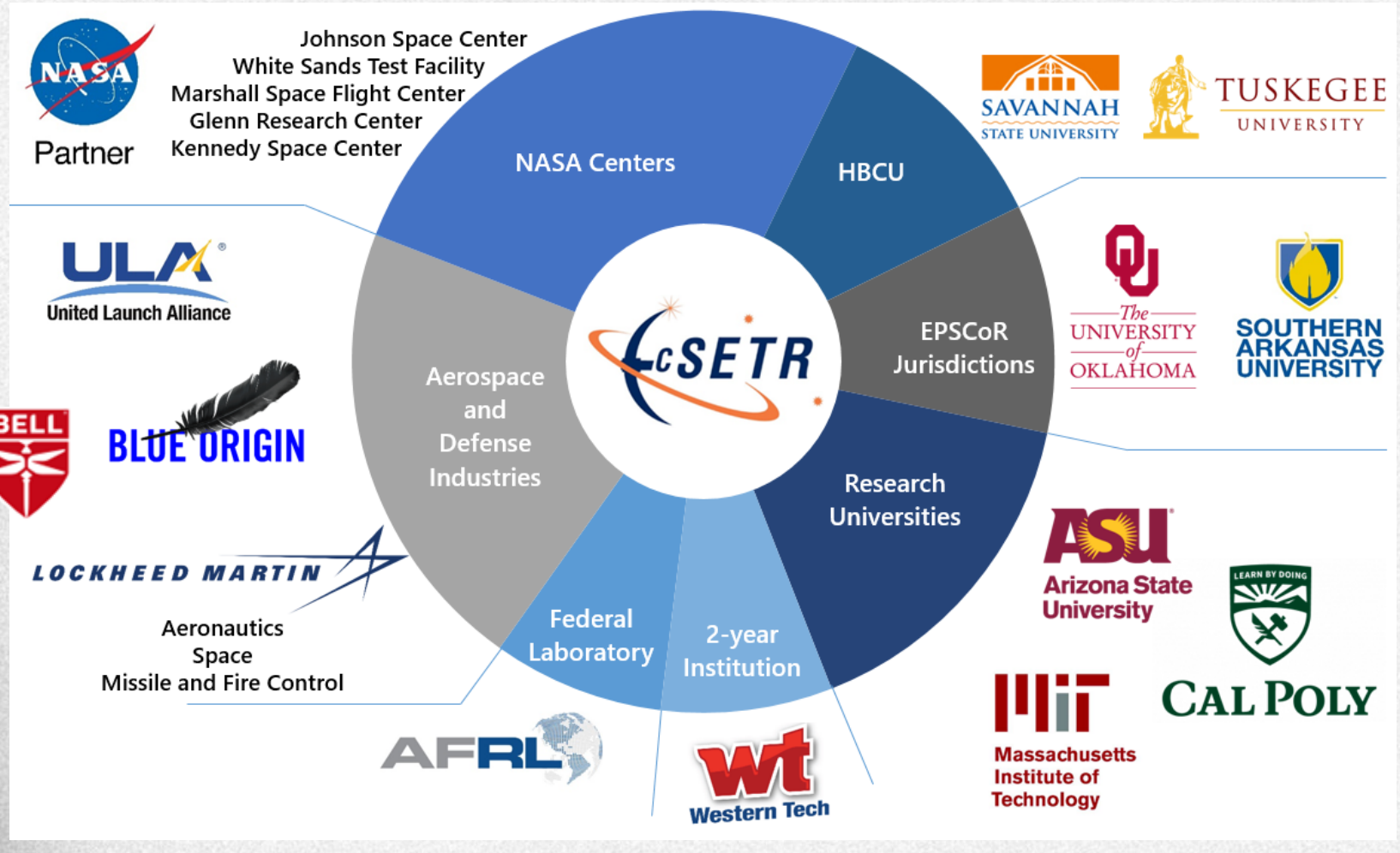
Horizon, TX

DEDC: Digital Engineering Aerospace and Defense Design Centers





STRATEGIC PARTNERS



New Digital Engineering Alliance

LOCKHEED MARTIN

PRAIRIE VIEW A&M UNIVERSITY
RESEARCH TEACHING SERVICE
PVAMU
1876

UNIVERSITAS 1881 TUSKEGEENSIS
SCIENTIA PRINCIPATUS OPERA

Build Back Better – Phase 2

Advanced Manufacturing Campus

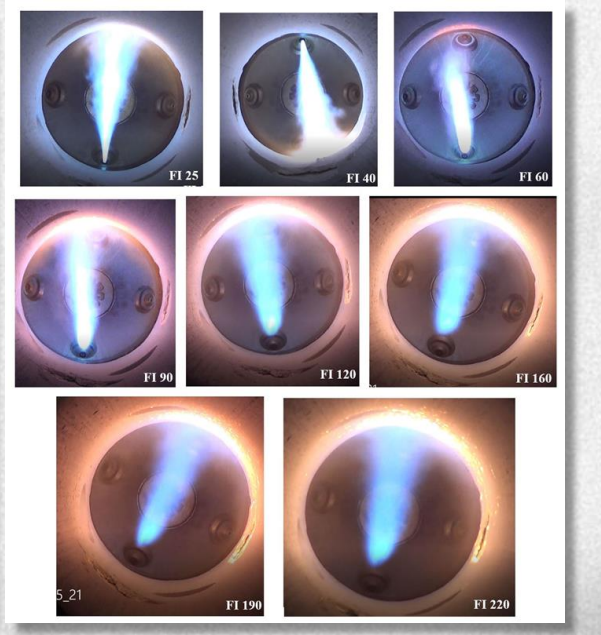
- 250 acre campus
- Master planned to co-locate aerospace, defense and advanced manufacturing
- Potential to minimize business expense through shared infrastructure
- Manufacturers can choose to locate their operations in a shared facilities or in single operator, designed-to-suit facilities

TECH ONE CAMPUS

UTEP AEROSPACE CENTER

AEROSPACE CENTER ENERGY RESEARCH PORTFOLIO

Swirl Flex Fuel Combustor

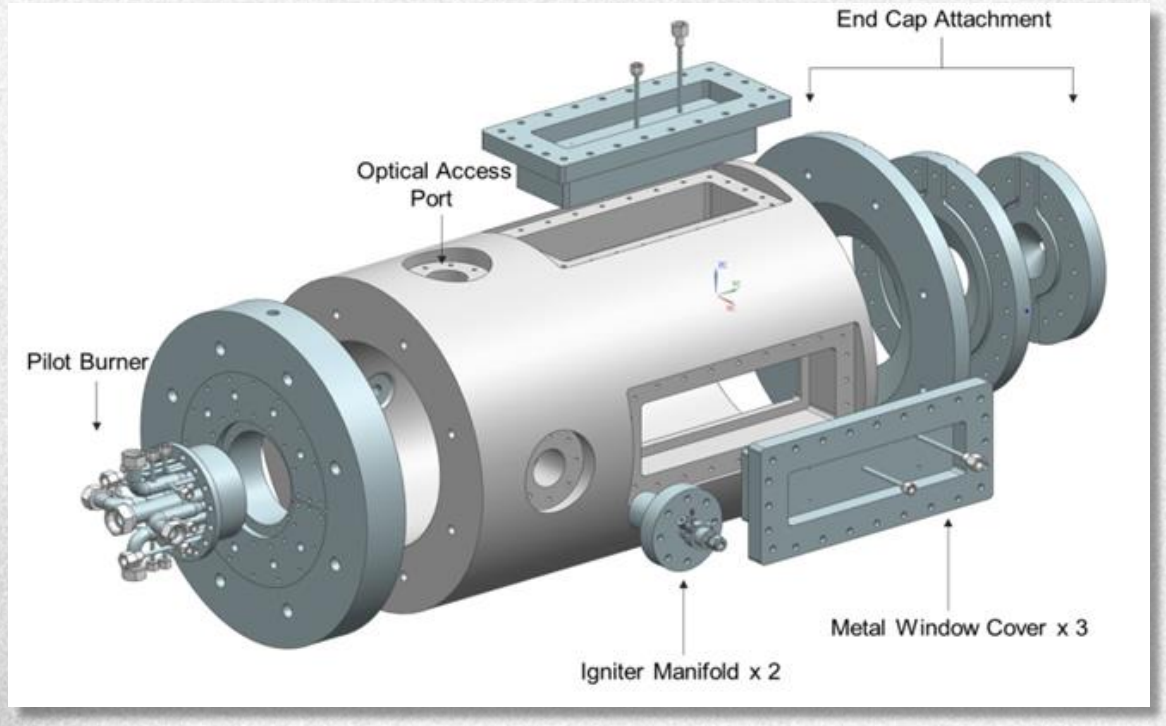


Up to 5 MW_{th} capacity
Modular design
Fuel flexible – Hydrogen, Syngas, Methane, Coal, Biomass, solid/fluid fuel-blends
Operating pressures up to 20 bar

AEROSPACE CENTER ENERGY RESEARCH PORTFOLIO

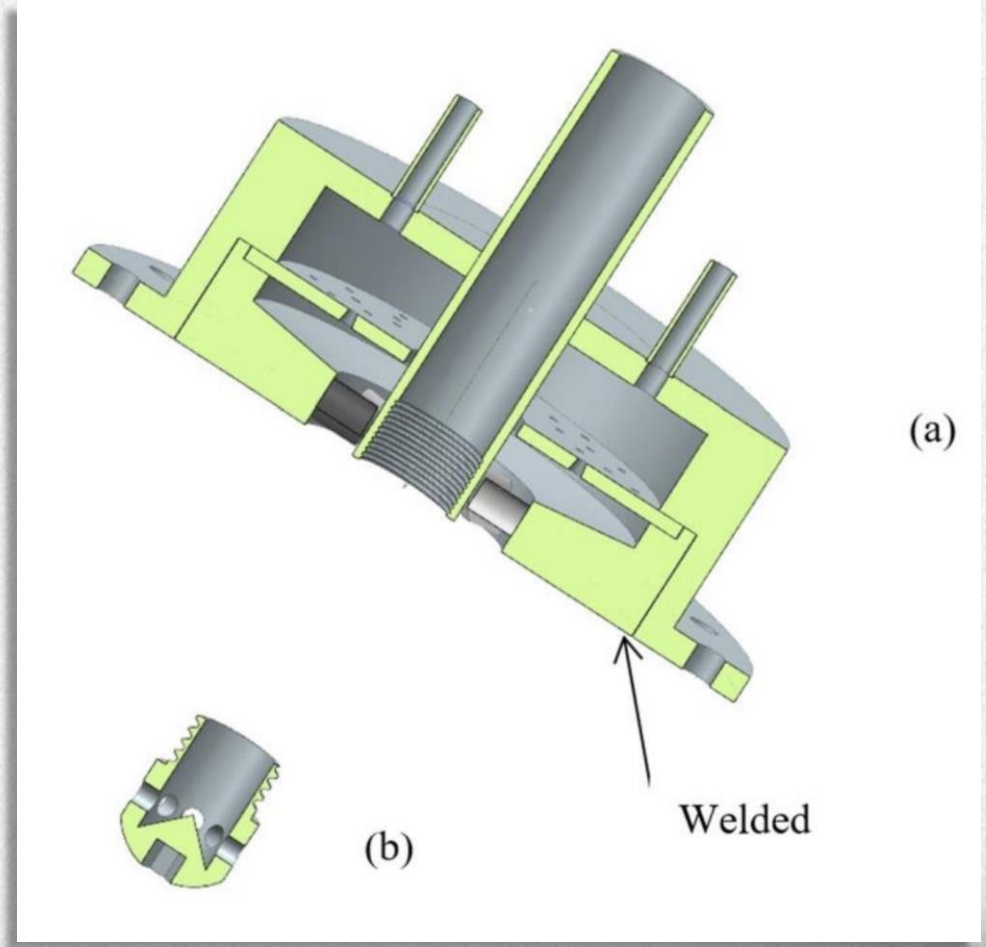
Intermediate Pressure Turbine Combustor

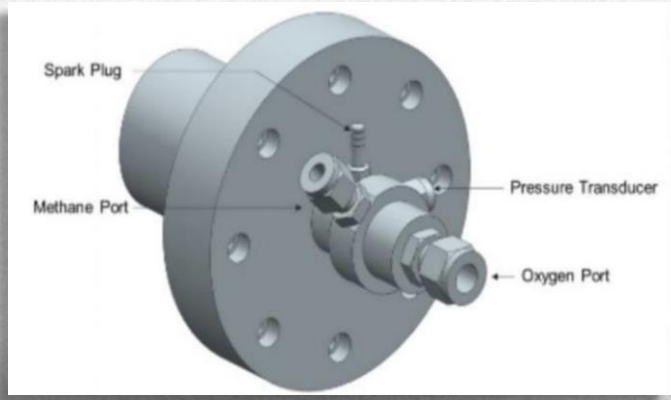
Up to 1 MW_{th} capacity
High operating pressure - up to 200 bar
Fuel flexible – Hydrogen, Syngas, Methane
High volume CO_2/RFG recirculation

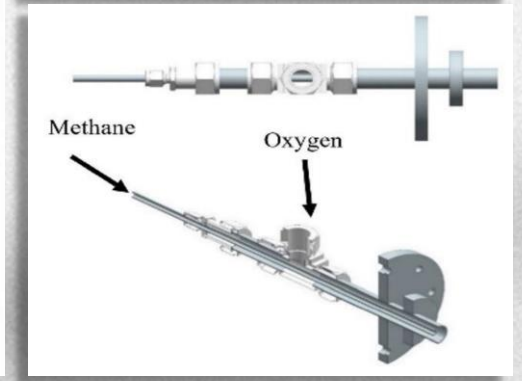


AEROSPACE CENTER ENERGY RESEARCH PORTFOLIO

Legacy Burner Systems







PROJECT PROGRESS

Task 2.1,2.2,2.3 (to be completed after completion of Task 1.3)

OBJECTIVE 2

Planning of hydrogen production research facility and future hydrogen research capabilities

2.1 Hydrogen Research Map

- Multi year Research Plan
- Potential funding source
- SME, Faculty and Student Roles

2.2 Required Resources

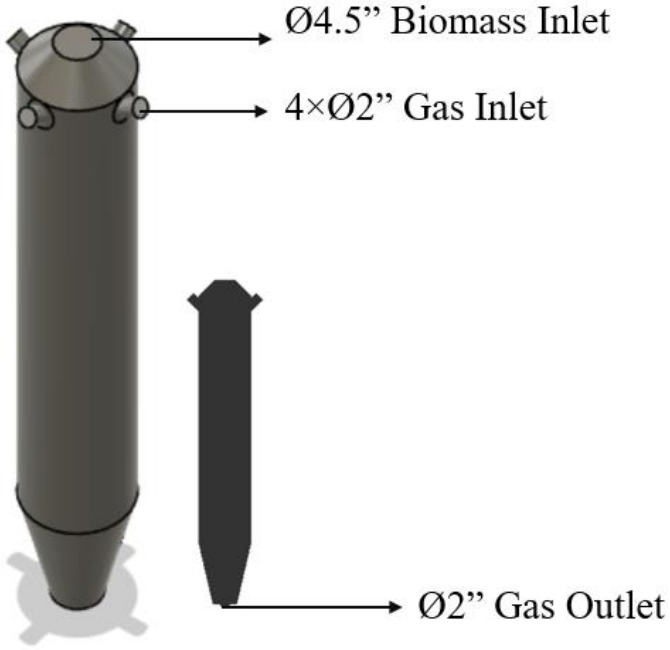
- Modification and use of existing resource
- New equipment and SME requirements
- Potential collaborations

2.3 Partnership and Outreach

- Community & local government partnerships
- K-12 outreach
- National labs and Industry collaborations

PROJECT PROGRESS

Task 3.1 & 3.3



Task 3.1: Student Training in the Gasifier Systems

Hydrogen seminars to expose students to gasification technologies

Planned during Summer 2023 and Fall 2023

Implemented CAD training to develop design competency

Task 3.3: Hydrogen Power Generation & Energy Systems Course Development

Course development underway

Course to be offered during Fall 2023 by the UTEP Aerospace and Mechanical Engineering Department

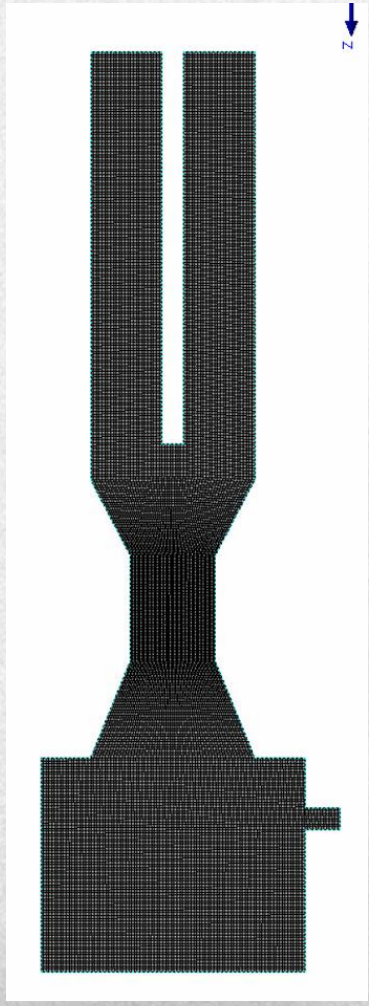
PROJECT PROGRESS

Task 3.2: Student Training in Gasifier Process Simulation

	Model	Settings	Information
Models Settings	Space	2D	-
	Time	Steady	-
	Viscous	Standard k-epsilon Turbulence model	Turbulence intensity = 10%
	Wall Treatment	Standard Wall Functions	-
	Specie Transport	Enabled	-
	Discrete Phase	Surface Injection	-

	Name	Type	Information
Boundary condition	Fluid	Fluid	Air(21%O_2)
	Outlet-syngas	Exhaust Fan	-
	Inlet Air	Mass flow inlet	0.00477 kg/s
	Wood inlet	Mass flow inlet	0.001944 kg/s
	Wall	Insulated	No-slip

Model Mesh



PROJECT PROGRESS

Task 3.2: Student Training in Gasifier Process Simulation

Model

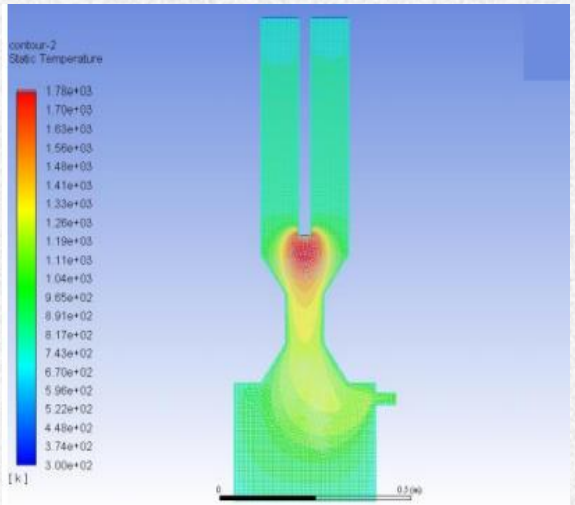


Figure 4 Temperature Contour for 0.4 ER

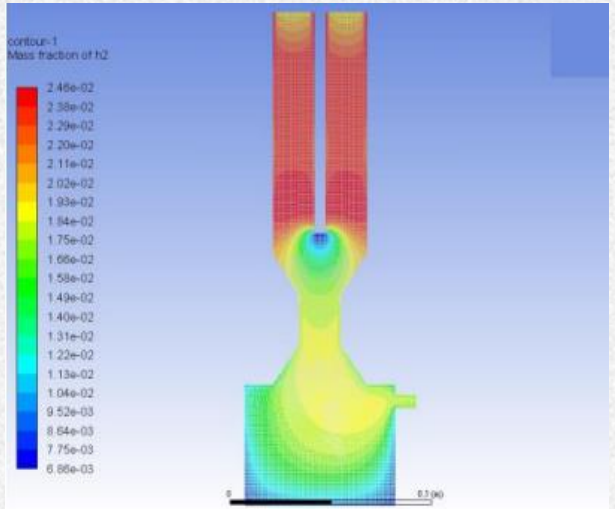


Figure 10 Mass Fraction of H_2 for 0.4 ER

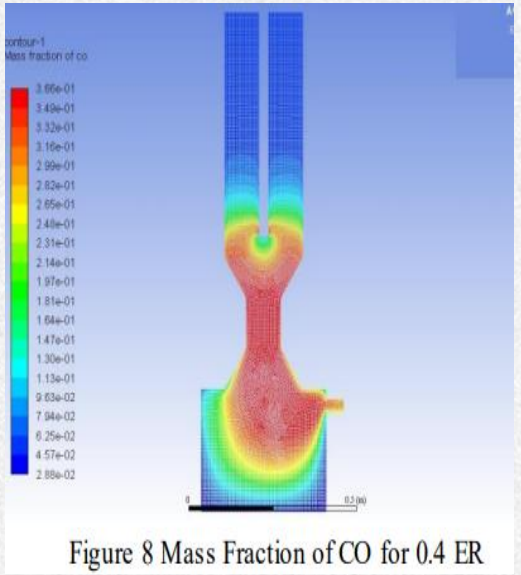
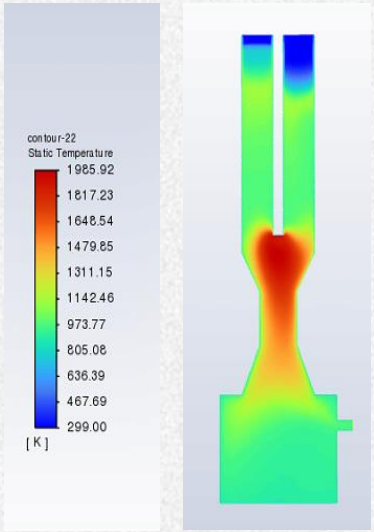
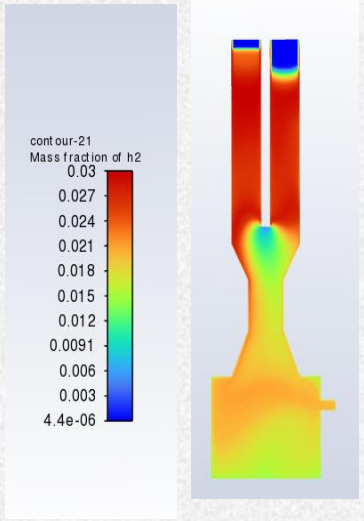
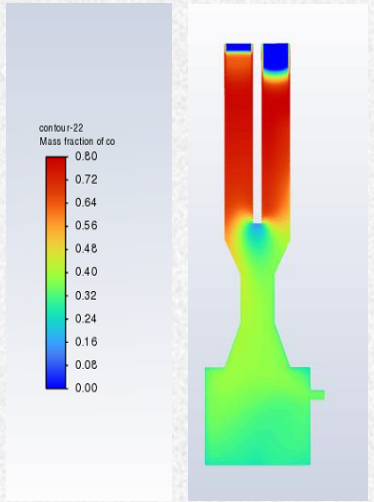


Figure 8 Mass Fraction of CO for 0.4 ER

Paper





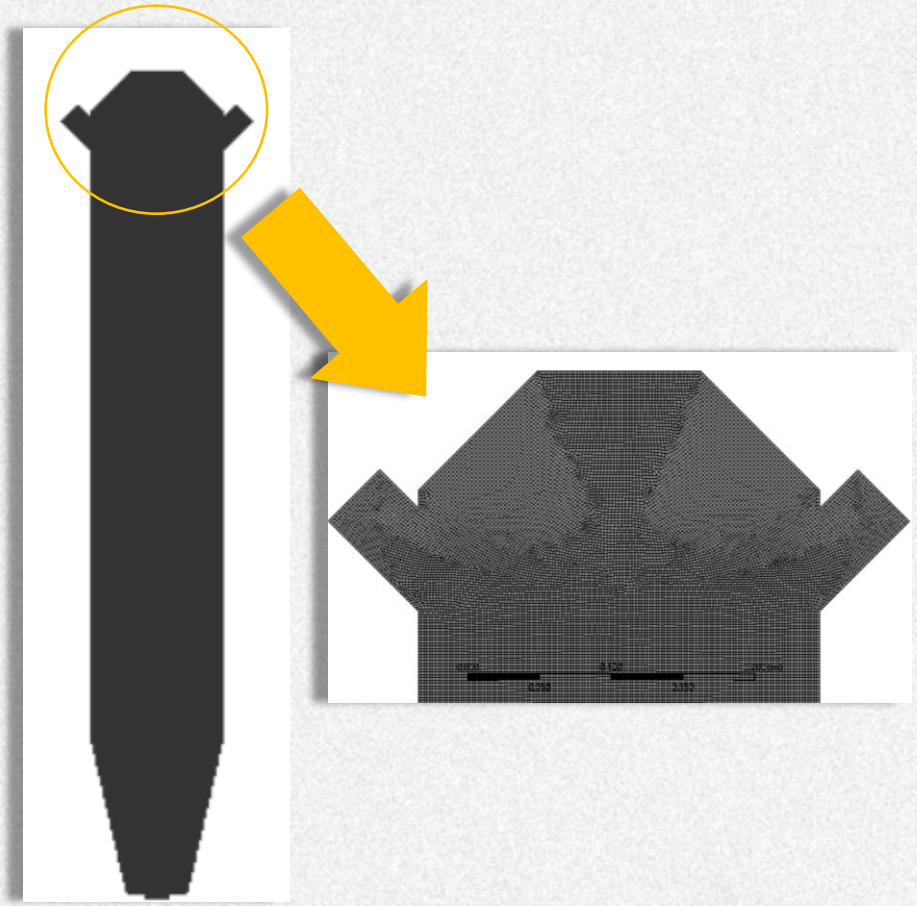


PROJECT PROGRESS

Task 3.2: Student Training in Gasifier Process Simulation

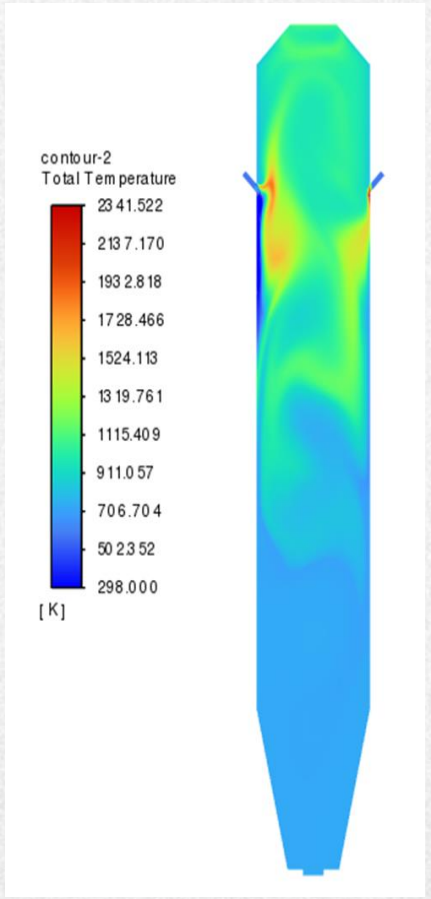
Boundary Conditions		
Study Type	Steady	Value
Solver Type	2D Planar	
Models	Standard K-epsilon Turbulence Model Species Transport Model, Standard Wall Functions, P-1 Radiation Model	Intensity: 5%
Gasifier	Downdraft	300 KW
Biomass Inlet	Combusting Mass Flowrate, 300K, 1 Atm	17.7g/s
Gas Agent Inlet	Air Flowrate (Varied with ER), 600K, 1 Atm	32.61g/s
Syngas Outlet	Exhaust Fan	

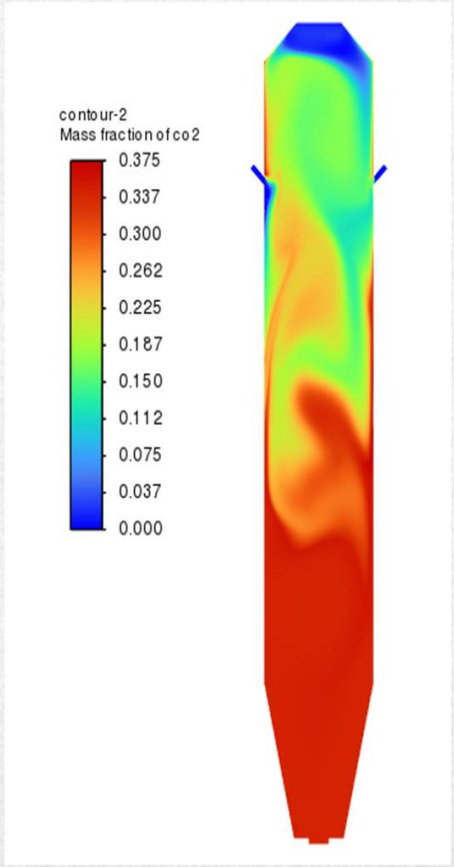
Model Mesh

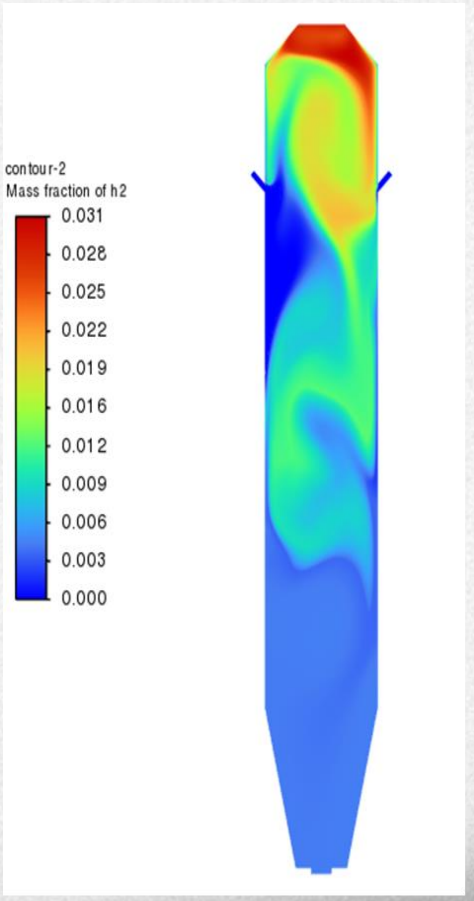


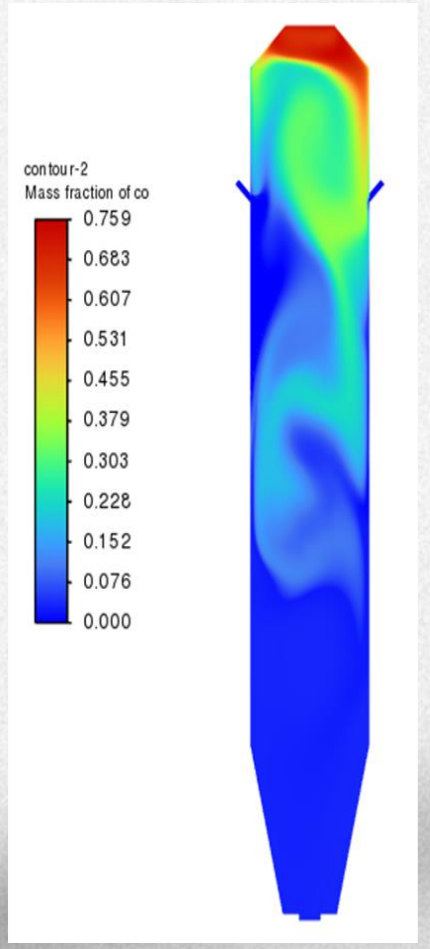
PROJECT PROGRESS

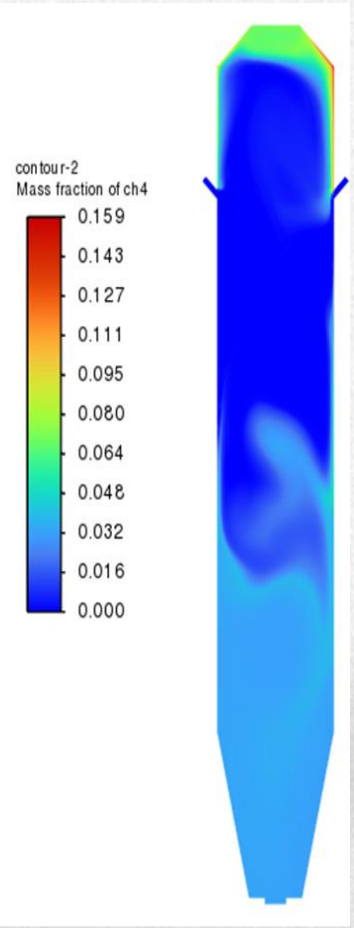
Task 3.2: Student Training in Gasifier Process Simulation





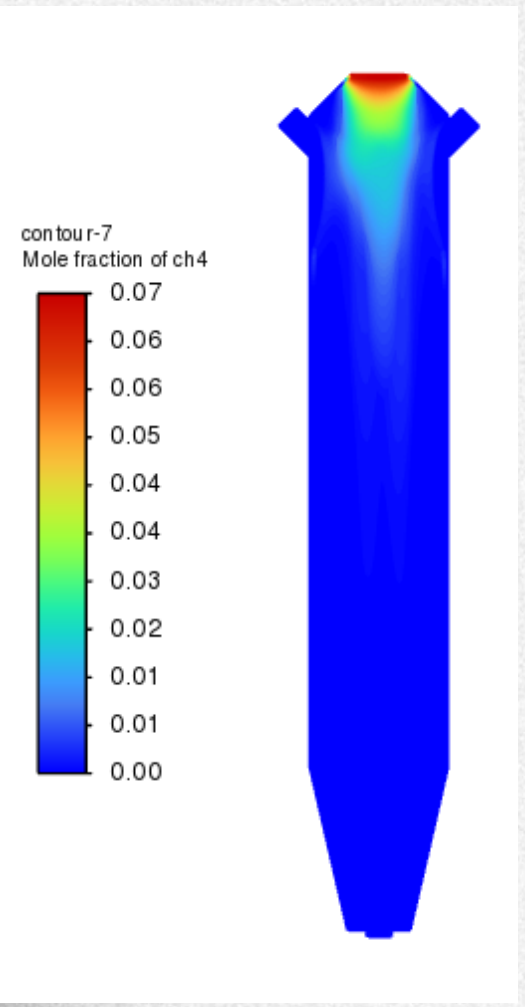


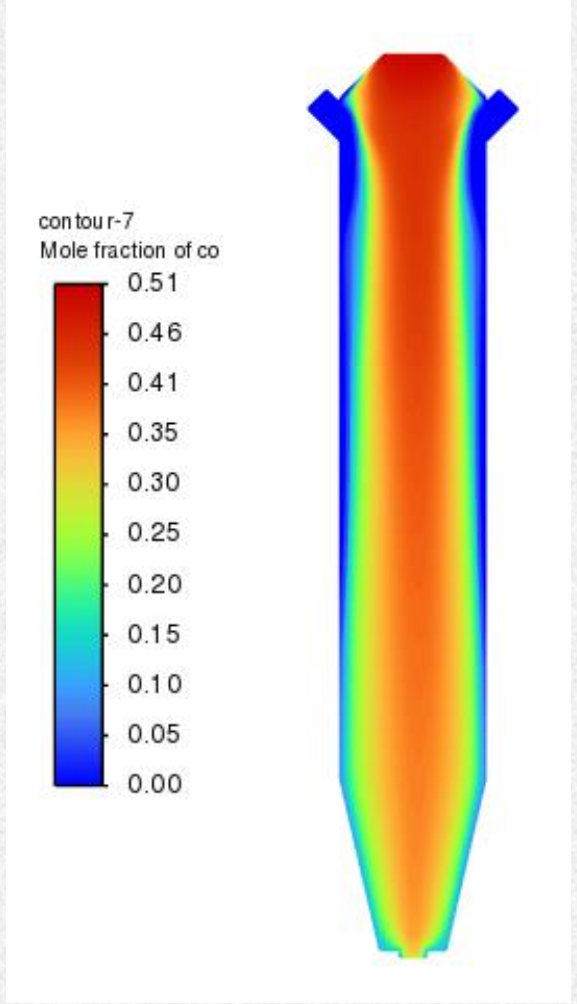


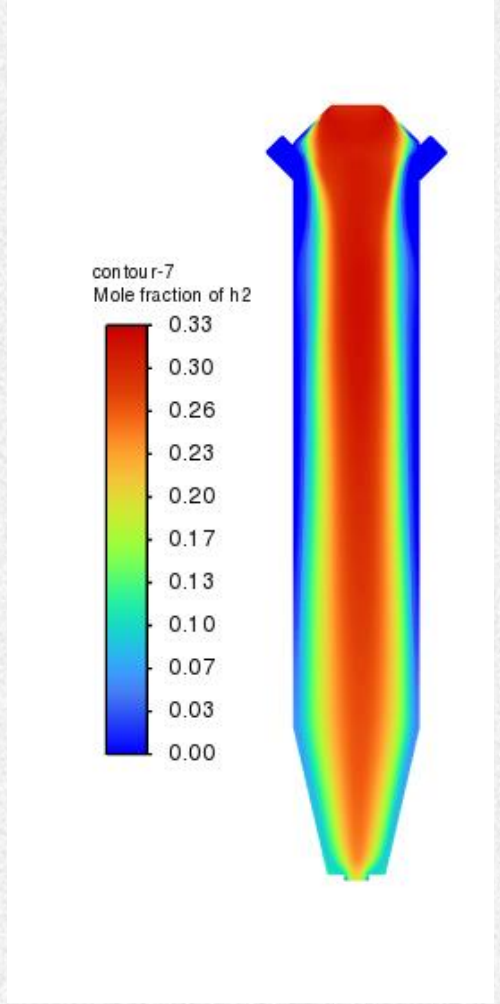


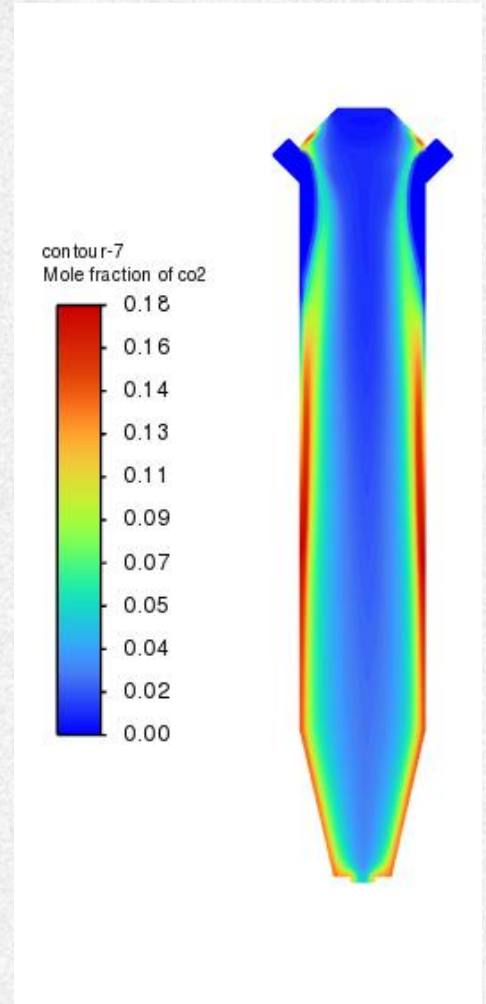
PROJECT PROGRESS

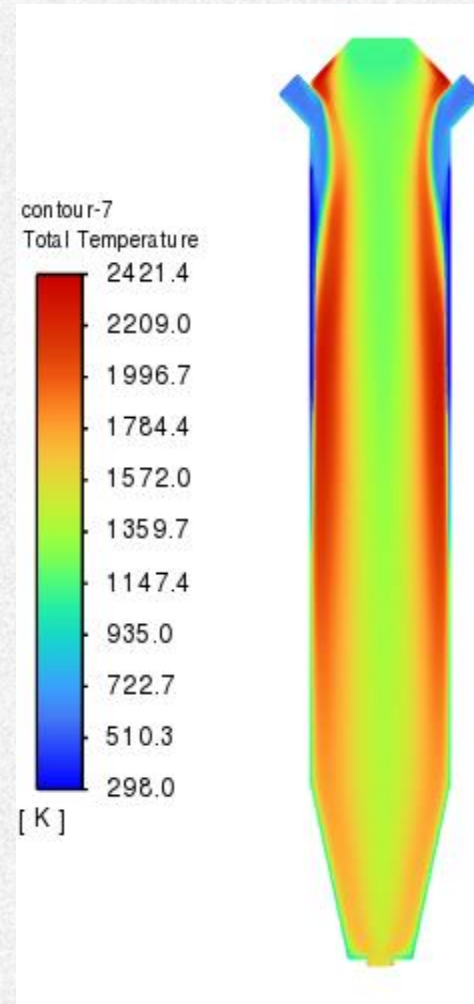
Task 3.2: Student Training in Gasifier Process Simulation











PUBLICATIONS

Southwest Emerging Technology Symposium 2023 (SETS 2023)

1. Tasnim, A.F., Chanda, S., Islam, N.A. and Choudhuri, A.R., 2023. **Towards a clean us energy: a systematic comparison between fossil power and sustainable hydrogen power.** Southwest Emerging Technology Symposium. (Paper Accepted)

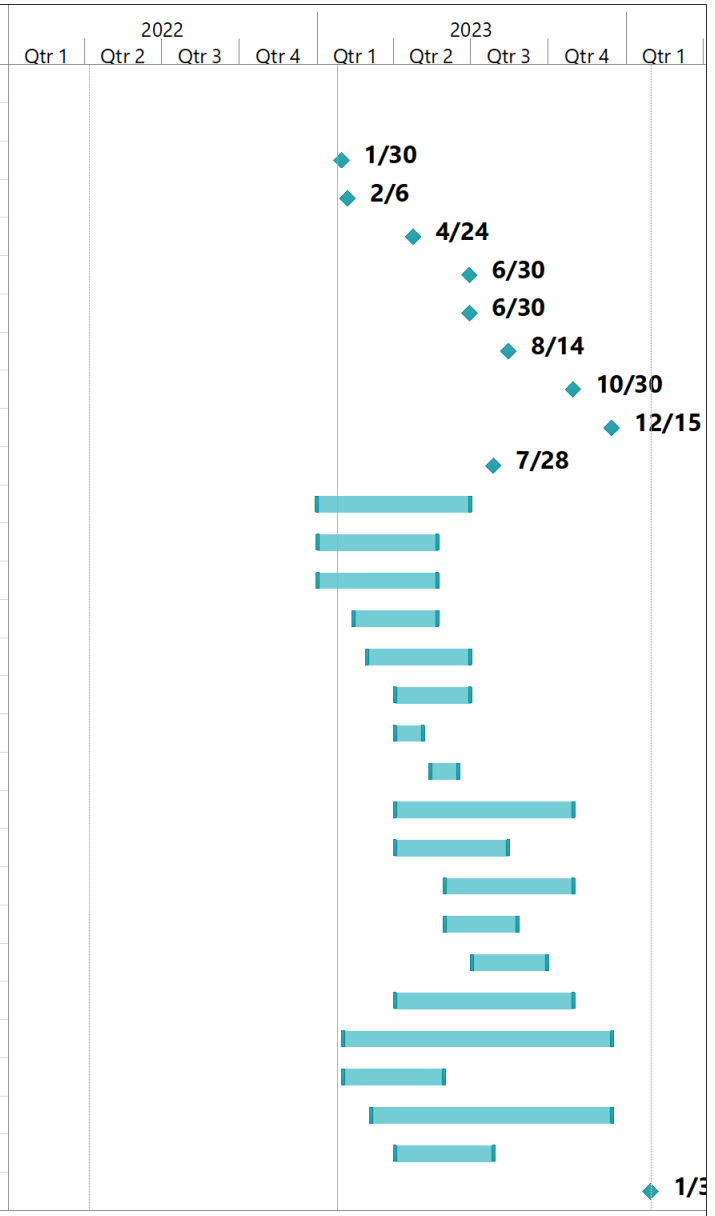
2. Chanda, S., Tasnim, A.F., Islam, N.A. and Choudhuri, A.R., 2023. **Sustainable energy resources in shaping the us energy: a review of the state-of-the-art, opportunities, challenges & ongoing technological development.** Southwest Emerging Technology Symposium. (Paper Accepted)

ASME International Mechanical Engineering Congress and Expo 2023 (IMECE 2023)

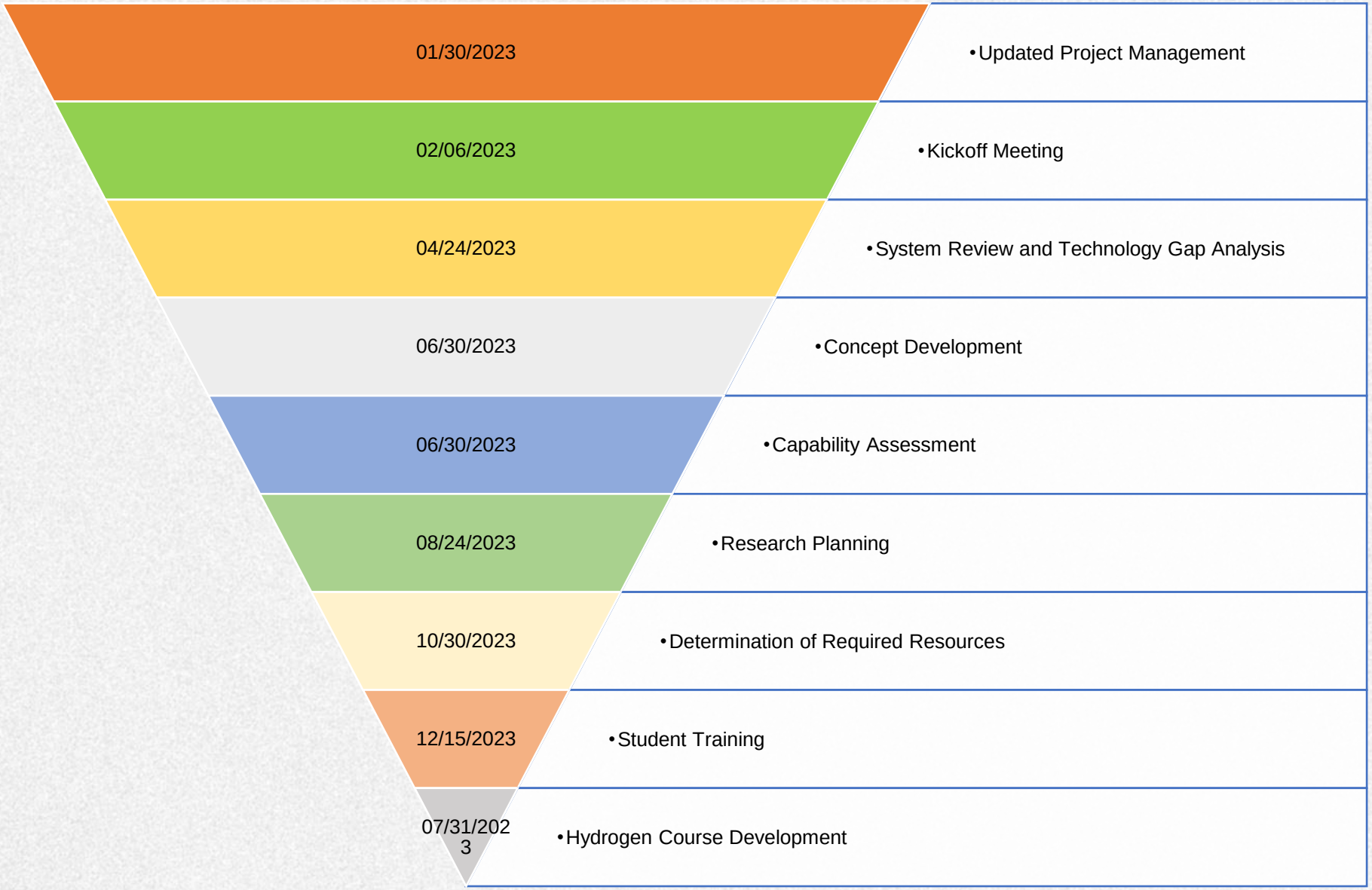
3. Chanda, S., Tasnim, A.F., Reyes, D., Choudhuri, A.R. and Islam, N.A., 2023. **A Computational Study of Sustainable Hydrogen Production Using High-Pressure Modular Gasifier.** ASME International Mechanical Engineering Congress and Exposition. (Abstract Accepted, Paper to be submitted in May)

TIMELINE

Task Name
Project Management Planning
Milestones
1. Update Project Management plan
1. Kick off meeting
1.1 system review and technology gap analysis
1.2 Concept Development
1.3 Capability Assessment
2.1 Research Planning
2.2 Determination of Resource Needed and Procuring plan
3.1,3.2 Student Training
3.3 Course Development on Hydrogen
1. Current state of the art gasification system analysis and capability assessment
1.1 System Review and Technology gap analysis
1.1.1. Gasifier design and system review
1.1.2. Technology Gap Analysis
1.2 Concept Development
1.3 UTEP Aerospace Center Capability Assessment
1.3.1 Subject Matter Expert Assesment
1.3.2 Facility, Equipment and Inventory Listing
2. Planning for Hydrogen Generation Research Facility and Future Research
2.1 Mapping of Hydrogen Research
2.2 Dermination of Resource needed, cost analysis and procuring plan
2.2.1 Determination of resource needed
2.2.2 Cost analysis and procuring plan
2.3. Developing Partnership and Outreach
3. Student Training and Education in Hydrogen Research and Gasifier System
3.1. Student Training in gasifier component design
3.2 Student training in gasifier modeling using ASPEN
3.3 Course development for hydrogen power and energy systems
Final Report



MILESTONE LOG



BUDGET

PROJECT EXPENSES				SEP 2022 - MAR 2023			PROJECT LIFE TO DATE; PERIOD ENDING: MAR 2023				
Project ID	Proj Descr	Budget Acct	Acct Descr	Pre-Enc	Enc	Expense	Budget	Pre-Enc	Enc	Expense	Available Budget
226160 678A	Capabilities Development at th	G6020	L6 Faculty Salaries Summer	$0.00	$0.00	$0.00	$5,436.00	$0.00	$0.00	$0.00	$5,436.00
226160 678A	Capabilities Development at th	G6030	L6 Staff Salaries	$0.00	$4,732.50	$2,839.50	$8,583.00	$0.00	$4,732.50	$2,839.50	$1,011.00
226160 678A	Capabilities Development at th	G6040	L6 Student Salaries	$0.00	$8,819.08	$7,981.10	$77,222.00	$0.00	$8,819.08	$7,981.10	$60,421.82
226160 678A	Capabilities Development at th	G6050	L6 Fringe Benefits	$0.00	$1,358.07	$2,193.61	$13,931.00	$0.00	$1,358.07	$2,193.61	$10,379.32
226160 678A	Capabilities Development at th	G6140	L6 Other Direct Costs	$0.00	$0.00	$851.50	$14,782.00	$0.00	$0.00	$851.50	$13,930.50
226160 678A	Capabilities Development at th	G6145	L6 Workshop-Seminar Costs	$0.00	$0.00	$0.00	$2,500.00	$0.00	$0.00	$0.00	$2,500.00
226160 678A	Capabilities Development at th	G6170	L6 Travel - Domestic	$0.00	$600.00	$767.14	$2,628.00	$0.00	$600.00	$767.14	$1,260.86
226160 678A	Capabilities Development at th	G6220	L6 Tuition & Fees (Stud Supp)	$0.00	$0.00	$0.00	$8,000.00	$0.00	$0.00	$0.00	$8,000.00
226160 678A	Capabilities Development at th	G6250	L6 F&A	$0.00	$0.00	$7,828.60	$66,918.00	$0.00	$0.00	$7,828.60	$59,089.40

SUCCESS CRITERIA

Decision Point	Success Criteria
Concept Development (1.2)	Completion of all tasks up to Task 1.2. Developing a feasible solution relevant to clean energy and carbon neutrality goals.
Capability Assessment (1.3)	Developing a list of expertise, and experience levels of affiliated faculties, research associates and engineers of the Aerospace Center. Developing a detailed list of equipment, software and facilities available at the Aerospace Center.
Determination of Resource Needed (2.2)	Completion of all tasks up to Task 2.2. Developing a detailed list of equipment and resources needed for the hydrogen research facility and the procurement options. Determining the subject matter experts required for current and future hydrogen research.
Student Training (3.1,3.2)	Improvement in student knowledge level in gasification. Improvement in student CAD and process simulation skills.
Course development for hydrogen (3.3)	Approval of course by the Mechanical and Aerospace Engineering department at the University of Texas at El Paso.

DELIVERABLES

Task / Subtask Number	Deliverable Title
1.1	Project Management Plan Update
2.1 – 2.3	R&D Scoping and capability assessment of the UTEP Aerospace Center (List of infrastructure, equipment and subject matter experts on disposal of UTEP Aerospace Center)
3.1	UTEP Aerospace Center Hydrogen research development plans
3.2 & 3.3	List of resources required (Infrastructure, equipment, personnel etc.)
4.1 & 4.2	Student training outcomes
4.3	Hydrogen courses for students

Thank You

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