ENVIRONMENTAL CONSIDERATIONS SUMMARY
CHESAPEAKE UTILITIES

Please provide a brief summary of the proposed project. *Describe proposed activities (not goals and objectives) and specify if this project is part of a larger project or connected to another project.*

The projects include: (1) Small-Scale Solar - Electrolysis H2 Production - H2 Fuel Station; (2) COD SMR H2 Fuel Cell Generation for Dover Air Force Base; (3) Safety Town Utility Training Facility - H2 Integration; (4) H2 Public Access Vehicle Fueling Station; (5) Purchase Hydrogen Trailers. Please refer to No. 4 below. Chesapeake will provide further information at a later date as the projects develop.

Is there ongoing or anticipated federal government involvement in any aspect of this project (e.g., funding, permitting, technical assistance, project located on federally administered land)? *If "yes," please list the agency and describe the nature of the involvement.*

Anticipated funding from the DOE via the Mid-Atlantic Clean Hydrogen Hub (MACH2) program. Also, the proposed COD SMR H2 Fuel Cell Generation project will provide service to the DOD's Dover Air Force Base and may require their technical assistance.

Is the project fully defined (i.e., all sites and activities are known)? *If "no", please describe the sites and/or activities/tasks that are yet to be defined.*

All potential sites and general activities have been identified. Chesapeake will provide further information at a later date as the projects develop.

Complete the table below for each location where proposed project activities would take place:

Proposed location (physical address or coordinates)	**Setting of the proposed location (e.g., urban, industrial, suburban, agricultural, university campus, manufacturing facility, etc.) and the current condition or use of the site**	**General description of the proposed activities**	**Land administration (e.g., federal [specify BLM, USFS, etc.], Tribal, state, local, private)**
East side of North RT 113 (NW/DuPont Boulevard), Georgetown, DE	Zoned AGR – Agriculture; currently vacant.	Small-Scale Solar - Electrolysis H2 Production - H2 Fuel Station. 70 acres of land has been purchased and solar field has been designed.	Private
Considered locations: 30 Lafferty Lane, Dover, DE and Kent County Industrial Park located on West side of Starlifter Ave., Dover, DE	Lafferty Lane: Zoned M – Manufacturing; currently vacant land. Starlifter Ave: Zoned IPM – Industrial Park Manufacturing;	COD SMR H2 Fuel Cell Generation for Dover Air Force Base. Fuel Cell Farm will be closely located to our existing Safety Town and Proposed Hydrogen Storage.	Private

	currently operates as Kent County Industrial Park.		
500-600 Energy Lane, Dover, DE	Zoned IPM – Industrial Park Manufacturing. Current use is commercial facility in Northgate Center owned/operated by Chesapeake Utilities Corp.	Safety Town Utility Training Facility - H2 Integration. Aligned with the Fueling Station as the piping will be tied into the hydrogen storage used for the fueling station. Piping will then tie into our Safety Town training center where it can be tested and researched as to how it can impact various piping, appliances, and meters and will also be incorporated into our leak survey educations and corrosion control.	Private
500-600 Energy Lane, Dover, DE	Zoned IPM – Industrial Park Manufacturing. Current use is commercial facility in Northgate Center owned/operated by Chesapeake Utilities Corp.	H2 Public Access Vehicle Fueling Station. Hydrogen storage and fueling will coincide with existing fueling infrastructure at our Energy Lane facility in Dover which was designed for large trucks. Land is already available and is strategically located close to RT1 and DelDOT.	Private
N/A	N/A	Hydrogen Trailers (Purchase) to deliver hydrogen. There are no additional costs included for the trucks which we already own and we have trained drivers available to perform deliveries.	N/A

Attach a map showing the location(s) of the proposed project, and a site layout map showing the proposed facilities and associated infrastructure. *(A GIS shapefile is preferable, if available.)*

A~650-acre property located east of U.S. Highway 9, referred to as the Finnegar Farm property, is outside the plant operational and previously disturbed areas except for a small area adjacent to U.S. Highway 9 and the Discharge Canal used as a barge landing for delivery of large components during OCNGS construction. This property is largely undeveloped and contains old fields, abandoned orchards, forests, wetlands, and marshlands. Portions of this property are controlled and owned by HDI. The remaining portions are controlled and owned by JCP&L. Road access to OCGS is via US Route 9, a two-lane paved road with a northeast-southwest orientation. To the west, the Garden State Parkway runs parallel to US Route 9. These two roads are intersected by Lacey Road (Ocean County Route 614), a two-lane paved road north of OCGS, and Warren Grove Road (Ocean County Route 532), a two-lane paved road south of OCGS. Employees traveling from the north or northwest of OCGS will use the Garden State Parkway, Lacey Road, and US Route 9 to reach the station. Employees traveling from the south or southwest of OCGS will use the Garden State Parkway, Warren Grove Road, and US Route 9 to reach the station. Employees traveling from the northeast will use New Jersey 37 and US 9 and employees traveling from the southeast will use New Jersey 72 and US 9. When nearing OCGS, all employees must use US Route 9.

In addition, a small area adjacent to Oyster Creek, east of Highway 9, was historically used as barge landing area to support historical site construction and operational activities. The current condition of the landing for Oyster Creek to support barging activities is not known and may require physical restoration and/or licensing obligations. Dredging between the barge landing and Barnegat Bay could also be required to provide enough depth for barge navigation. Current OCNGS utilities consist of natural gas supplied by New Jersey Natural Gas Company, water and sewer supplied by Lacey Municipal Utilities Authority, and electric supplied by JCP&L. In addition, two on-site production wells with a total pumping capacity of approximately 425 gallons per minute support plant operations. It is not clear at this time to what extent these utilities will be present at OCNGS after decommissioning. However, it is anticipated that some or all current utilities will be available to support ISFSI operations and other proposed property repurposing endeavors.

Identify and describe any existing, modifications to, or new permits, licenses, or authorizations that would be required to perform project activities. *(e.g., environmental permits, operating permits, or drilling permits)*

Environmental permits and operating permits to be determined during Phase I of the project.

Provide a brief description of the existing environmental burdens at the proposed project location(s) and surrounding areas, including those contributed to or exacerbated by existing facilities the H2Hub will leverage or modify. *Existing environmental burdens can be identified using available tools, such as DOE's Energy Justice Dashboard (beta) (https://www.energy.gov/diversity/energy-justice-dashboard-beta) or the U.S. Environmental Protection Agency's EJSCREEN (https://www.epa.gov/ejscreen).*

This will be determined during Phase 1 of the project.

Would any of the following have the potential to be impacted (directly or indirectly) by the proposed project? *If "yes", provide a detailed description of: (1) the resources that could be affected, and (2) how project activities may affect those resources (including potential direct and indirect [visual, noise, etc.] impacts).*

- Tribal lands or resources of Tribal interest and/or sensitivity
- Environmental Justice (EJ) Populations (EJ populations include minority, low-income, and Tribal populations)
- Historic, archeological, or cultural resources (includes listed and eligible resources over 50 years old or of cultural significance)
- Areas having a special designation (e.g., federal and state designated wilderness areas, national parks, national natural landmarks, wild and scenic rivers, state and federal wildlife refuges, and marine sanctuaries)
- Threatened or endangered species (whether proposed or listed by state or Federal governments), including their habitat
- Land resources (e.g., prime farmland, unique farmland, or other farmland of statewide or local importance, tundra, rainforests)
- Floodplains
- Wetlands
- Air quality (indoor and/or outdoor)
- Greenhouse gas emissions
- Water quality (surface and/or ground water and/or special sources of water including sole source aquifers)
- Ocean resources (e.g., coral reefs)
- Coastal zones
- Marine mammals or essential fish habitat
- Land use
- Socioeconomic conditions
- Sensitive receptors (e.g., hospitals, schools, daycare facilities, elderly housing)
- Navigable Airspace
- Transportation infrastructure

Within the Pinelands National Reserve, the OCNGS site is in Lacey and Ocean Townships, Ocean County, on the southeastern coast of New Jersey, and about nine miles south of Toms River, New Jersey. Ocean County occupies an area of 638 square miles. Land use in the county is primarily forest (45 percent of total land area), recreation (16 percent), and government (16 percent), with a smaller land area occupied by residential (7 percent), industrial (3 percent), and commercial land uses (1 percent).

Most of the area in the immediate vicinity of the OCNGS site consists of abandoned farmland (65 percent), forested land (25 percent), and surface water (10 percent). In general, only about 25 percent of the land in the surrounding area is developed because development within the Pinelands National Reserve is strictly controlled.

The nearest population center is Forked River Beach housing development, located on the shoreline at the mouth of Forked River, approximately one mile east of the OCNGS site. The OCNGS site is in the Pinelands National Reserve and is adjacent to Barnegat Bay. A State game farm located approximately two miles north of the site is used for raising quail and pheasant.

The following information was gleaned from environmental reports associated with OCNGS operation and was used to inform land designations at and surrounding the Oyster Creek site.

The New Jersey Pinelands (or Pine Barrens) contain over a million acres of pine-oak forests, streams and rivers, farms, crossroad hamlets, and small towns stretched across southern New Jersey. All or portions of seven counties and 52 municipalities in New Jersey are located within the Pinelands Area (Township of Lacey 1991). The OCNGS site is located within the Pinelands National Reserve.

As of 2002, the National Register of Historic Places listed 27 locations in Ocean County, New Jersey (U.S. Department of the Interior 2004). Of these 27 locations, 5 fall within a 6-mile radius of OCGS. The list below identifies the five National Register of Historic Places sites within the 6-mile radius of OCGS. The Historic Preservation Office of the NJDEP lists approximately 100-110 additional sites, including maritime vessels, of historical significance within Ocean County (NJDEP 2004d).

- Barnegat Light Public School – 501 Central Ave., Barnegat Light
- Barnegat Lighthouse – North end of Long Beach Island, off Broadway., Ave, Barnegat Light
- Double Trouble Historic District – South of Beachwood off Garden State Parkway, Beachwood
- Falkinburg Farmstead – 28 Westcott Avenue, Ocean Township, Waretown
- Manahawkin Baptist Church – North Main Street (US 9) and Lehigh Avenue, Manahawkin

The OCGS site contains a largely undeveloped buffer strip of approximately 60 acres that lies parallel to US Route 9. This 60-acre parcel was the subject of a threatened and endangered habitat assessment in the spring and summer of 2004. A small area of emergent/scrub-shrub and forested wetlands lies in the southern part of this tract, adjacent to the discharge canal. Finnegar Farm is a largely undeveloped 650-acre tract that provides a mix of terrestrial and wetland habitats and supports a variety of wildlife. The property, formerly a cattle farm, was purchased by JCP&L in 1966. The study included a Natural Resources Inventory to aid in future planning efforts. The National Resources Inventory mapping determined that 10 percent of the property was covered with surface water, and the rest of the property was forested (25 percent) or abandoned farmland (65 percent). The eastern one-third of the site consisted of drained coastal wetlands that had been invaded by the giant reed (Phragmites australis).
A comprehensive review of threatened and endangered terrestrial species in the OCNGS area was conducted in 2004 in support of proposed national security upgrades. The assessment included a review of the NJDEP Natural Heritage Program records, maps of threatened and endangered species habitat and occurrences and other records. The barred owl (Strix varia), Cooper's hawk (Accipter cooperii), northern pine snake (Pituophos m. melanoleucus), pine barrens treefrog (Hyla andersoni) and wood turtle (Clemmy's insculpta) were identified as occurring in the site area. None were detected during a field survey conducted to determine if the species were present in the site area.

Please describe:

- any coordination or discussions that have been initiated or the plan to coordinate with state and/or federal agencies *(e.g., State Historic Preservation Office, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, Nuclear Regulatory Commission, etc.)*

This will be completed during Phase 1 of the project.

- any coordination or discussions that have been initiated with any Tribal governments

This will be completed during Phase 1 of the project.

- any issues that would generate public controversy regarding proposed project

This will be completed during Phase 1 of the project.

- any studies, reviews, and/or plans that have been completed for the proposed project *(e.g., environmental site assessments, waste management plans, health and safety plans, cultural resource surveys, identification of prime or unique farmland, wildlife surveys, etc.)*

This will be completed during Phase 1 of the project.

- any environmental considerations and/or mitigation strategies that have been incorporated into the proposed project *(e.g., measures to reduce and/or avoid greenhouse gas emissions, and/or impacts to cultural resources, historic properties, state or federally protected species, wetlands, floodplains, traffic, ambient noise, etc.)*

This will be completed during Phase 1 of the project.

- any discussions with affected communities

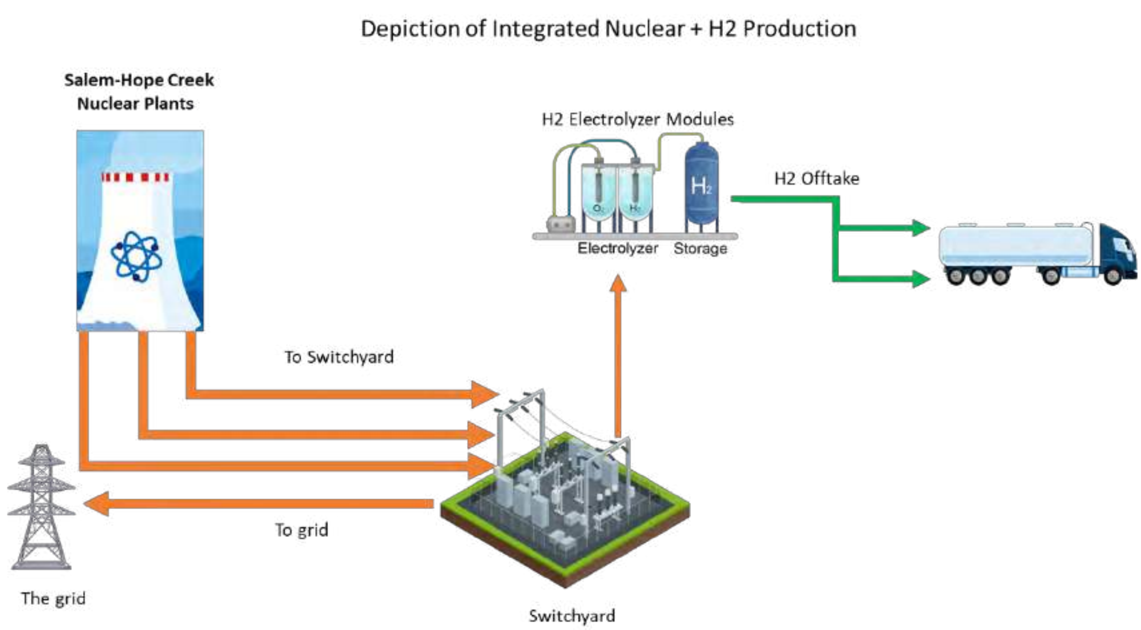
This will be completed during Phase 1 of the project.

ENVIRONMENTAL CONSIDERATIONS SUMMARY
HOLTEC – SALEM-HOPE CREEK

Please provide a brief summary of the proposed project. *Describe proposed activities (not goals and objectives) and specify if this project is part of a larger project or connected to another project.*

The Salem-Hope Creek Hydrogen Generation Project is designed to showcase the use of nuclear reactor developed electrical power linked to an electro hydrolysis unit for the production of Hydrogen. The manufactured Hydrogen will either move by truck to a distribution point in the Mid-Atlantic Hub infrastructure being developed.

The Salem-Hope Creek complex is a site with two existing nuclear plants. The complex is located on a 740-acre site in Salem County, NJ. The Salem-Hope Creek plants are owned and operated by PSEG. The plan is to conduct Hydrogen generation by electrical separation. The Holtec Salem-Hope Creek site will serve as the location for the hydrogen production hub, with electrical output from Salem-Hope Creek complex's three reactors generated on-site.



Depiction of Integrated Nuclear + H2 Production

Is there ongoing or anticipated federal government involvement in any aspect of this project (e.g., funding, permitting, technical assistance, project located on federally administered land)? *If "yes," please list the agency and describe the nature of the involvement.*

No, there is no anticipated federal government involvement.

Is the project fully defined (i.e., all sites and activities are known)? *If "no", please describe the sites and/or activities/tasks that are yet to be defined.*

Yes, the project is fully defined.

Complete the table below for each location where proposed project activities would take place:

Proposed location (physical address or coordinates)	Setting of the proposed location (e.g., urban, industrial, suburban, agricultural, university campus, manufacturing facility, etc.) and the current condition or use of the site	General description of the proposed activities	Land administration (e.g., federal [specify BLM, USFS, etc.], Tribal, state, local, private)
Salem / Hope Creek	Rural (existing nuclear power plant site)	Use of a new generation pressurized water reactor linked to an electro hydrolysis unit for the production of Hydrogen	Private

Attach a map showing the location(s) of the proposed project, and a site layout map showing the proposed facilities and associated infrastructure. *(A GIS shapefile is preferrable, if available.)*

The site location and layout maps will be provided during Phase 1 of the project.

Describe new facilities to be constructed, any modifications of existing facilities, and any new infrastructure or facilities necessary for the construction or operation of the proposed project. *(e.g., access roads, laydown areas, off-site parking areas, railroad links, docks, water outfalls and intakes, pipelines, electrical transmission, waste treatment facilities, etc.)*

Any new facilities or modifications of existing facilities will be determined Phase 1 of the project.

Identify and describe any existing, modifications to, or new permits, licenses, or authorizations that would be required to perform project activities. *(e.g., environmental permits, operating permits, or drilling permits)*

Environmental permits and operating permits to be determined during Phase I of the project.

Provide a brief description of the existing environmental burdens at the proposed project location(s) and surrounding areas, including those contributed to or exacerbated by existing facilities the H2Hub will leverage or modify. *Existing environmental burdens can be identified using available tools, such as DOE's Energy Justice Dashboard (beta) (https://www.energy.gov/diversity/energy-justice-dashboard-beta) or the U.S. Environmental Protection Agency's EJSCREEN (https://www.epa.gov/ejscreen).*

This will be determined during Phase 1 of the project.

Would any of the following have the potential to be impacted (directly or indirectly) by the proposed project? *If "yes", provide a detailed description of: (1) the resources that could be affected, and (2) how project activities may affect those resources (including potential direct and indirect [visual, noise, etc.] impacts).*

- Tribal lands or resources of Tribal interest and/or sensitivity
- Environmental Justice (EJ) Populations *(EJ populations include minority, low-income, and Tribal populations)*
- Historic, archeological, or cultural resources *(includes listed and eligible resources over 50 years old or of cultural significance)*
- Areas having a special designation *(e.g., federal and state designated wilderness areas, national parks, national natural landmarks, wild and scenic rivers, state and federal wildlife refuges, and marine sanctuaries)*
- Threatened or endangered species *(whether proposed or listed by state or Federal governments)*, including their habitat
- Land resources *(e.g., prime farmland, unique farmland, or other farmland of statewide or local importance, tundra, rainforests)*
- Floodplains
- Wetlands
- Air quality *(indoor and/or outdoor)*
- *Greenhouse gas emissions*
- Water quality *(surface and/or ground water and/or special sources of water including sole source aquifers)*
- Ocean resources *(e.g., coral reefs)*
- Coastal zones
- Marine mammals or essential fish habitat
- Land use
- Socioeconomic conditions
- Sensitive receptors *(e.g., hospitals, schools, daycare facilities, elderly housing)*
- Navigable Airspace
- Transportation infrastructure

Any potential environmental impacts such as these will be determined during Phase 1 of the project.

Please describe:

- any coordination or discussions that have been initiated or the plan to coordinate with state and/or federal agencies *(e.g., State Historic Preservation Office, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, Nuclear Regulatory Commission, etc.)*

This will be completed during Phase 1 of the project.

- any coordination or discussions that have been initiated with any Tribal governments

This will be completed during Phase 1 of the project.

- any issues that would generate public controversy regarding proposed project

This will be completed during Phase 1 of the project.

- any studies, reviews, and/or plans that have been completed for the proposed project *(e.g., environmental site assessments, waste management plans, health and safety plans, cultural resource surveys, identification of prime or unique farmland, wildlife surveys, etc.)*

This will be completed during Phase 1 of the project.

- any environmental considerations and/or mitigation strategies that have been incorporated into the proposed project *(e.g., measures to reduce and/or avoid greenhouse gas emissions, and/or impacts to cultural resources, historic properties, state or federally protected species, wetlands, floodplains, traffic, ambient noise, etc.)*

This will be completed during Phase 1 of the project.

- any discussions with affected communities

This will be completed during Phase 1 of the project.

ENVIRONMENTAL CONSIDERATIONS SUMMARY
MONROE ENERGY

Please provide a brief summary of the proposed project.

Monroe Energy: 3 Projects

A. A New H2 plant is being designed and constructed at Monroe Energy current refinery plant site Trainer, PA to provide H2 to

B. New SAF (Sustainable Aviation Fuel) plant which is also designed and constructed at Monroe Energy refinery site Trainer, PA.
Note: SAF Feed pre-treatment facility site location TBD in near future.

The H2 plant is connected/tied to the SAF unit operations.

C. H2 End user – will be designed and constructed at Monroe Energy current refinery plant site Trainer, PA to redesign existing equipment to utilize H2 on applicable equipment (i.e. heaters, boilers, etc.). The H2 will be supplied and connected either expanding Monroe's new H2 plant or leveraging the possible new H2 regional MACH 2 supply hub.

Is there ongoing or anticipated federal government involvement in any aspect of this project (e.g., funding, permitting, technical assistance, project located on federally administered land)?

No

Is the project fully defined (i.e., all sites and activities are known)?

Yes: We have already processed a FEL 1 and moving into FEL 2 project development process for A. new H2 plant and B. New SAF with Feed Pre-Treatment facility. However, the site for the Feed Pre-treatment facility will be finalized in the FEL 2 project process. C. H2 end user will start in the future 2025 for FEL 1 project process to install in 2028.

Complete the table below for each location where proposed project activities would take place:

Proposed location (physical address or coordinates)	Setting of the proposed location (e.g., urban, industrial, suburban, agricultural, university campus, manufacturing facility, etc.) and the current condition or use of the site	General description of the proposed activities	Land administration (e.g., federal [specify BLM, USFS, etc.], Tribal, state, local, private)
Monroe Energy LLC: Refinery:	Currently a manufacturing and industrial permitted refinery site	Construct a new H2 plant, SAF unit (Feed Pre-treatment site TBD) , and H2 end	N/A

4101 Post Rd, Marcus Hook, PA 19061		use future projects on Monroe Refinery site	

Attach a map showing the location(s) of the proposed project, and a site layout map showing the proposed facilities and associated infrastructure. *(A GIS shapefile is preferrable, if available.)*

(See addendum Question # 5)

Describe new facilities to be constructed, any modifications of existing facilities, and any new infrastructure or facilities necessary for the construction or operation of the proposed project.

a. A New H2 plant (Steam Methane Reformer)- SMR) is being designed and constructed at Monroe Energy current refinery plant site Trainer, PA to provide H2.
   Note: There are no new infrastructure required for any of these three projects since existing infrastructure already in place at Monroe Refinery site

b. New SAF (Sustainable Aviation Fuel) plant which is also being designed and constructed at Monroe Energy refinery site Trainer, PA. to add new equipment and modifying existing equipment.
   1. Note: SAF Feed pre-treatment facility site location TBD in near future depending on location could require further WWTP capacity, etc.
   2. Note: The H2 plant is connected/tied to the SAF unit operations.

c. H2 End user – will be designed and constructed at Monroe Energy current refinery plant site Trainer, PA to redesign existing equipment to utilize H2 on applicable equipment (i.e. heaters, boilers, etc.).
   Note: The H2 will be supplied and connected either expanding Monroe's new H2 plant or leveraging the possible new H2 regional MACH 2 supply hub.
   (e.g., access roads, laydown areas, off-site parking areas, railroad links, docks, water outfalls and intakes, pipelines, electrical transmission, waste treatment facilities, etc.)

Identify and describe any existing, modifications to, or new permits, licenses, or authorizations that would be required to perform project activities.

Critical permit/contract type needed	Expected time to get permit/contract	Current status (e.g., not started, in progress, completed)
1. Environmental PADEP Plan Approval (Air compliance): Non-PSD	12-18 months – after submittal	FEL 2 Technology package development starting: Permit not started/submitted A. H2 plant B. SAF unit

	TBD – Non-PSD or PSD	C. SAF Pretreatment unit H2 End user: FEL 1 starts 2025
2. Environmental PADEP/DCCD Chapter 102 Permit approval (Storm Water Discharge)	6-8 months – after submittal	FEL 2 Technology package development starting: Permit not started/submitted A. H2 plant B. SAF unit C. SAF Pretreatment unit
3. Environmental Potential – Chapter 105 permit (Stream Control) 4. NPDES (WWTP) potential revision to existing permit 5. SAF Pre-treatment – TBD: site location	9-12 months- after submittal 6 months – after submittal TBD – 12-18 months (Non-PSD) and if PSD (24-27 months)	FEL 2 Technology package development starting: Permit not started/submitted A. H2 plant B. SAF unit C. SAF Pretreatment unit

	Site location/pipeline [if applicable]	**Do you have site control? Y/N? (If N, please add to above table)**
Project site	Trainer, PA Monroe Energy LLC refinery Exception – SAF (Sustainable Aviation Fuel) Pre-treatment site location TBD	Yes exception is SAF (Sustainable Aviation Fuel) Pretreatment site location –TBD
Pipeline/Delivery project [if applicable]	N/A	N/A

Provide a brief description of the existing environmental burdens at the proposed project location(s) and surrounding areas, including those contributed to or exacerbated by existing facilities the H2Hub will leverage or modify.

Known environmental burdens include:

- *Proximity to an environmental justice area (95-100th percentile for PM2.5, for example, per EPA's EJscreen tool)*
- *Site deed restrictions and covenants due to legacy contamination. The site has worked with legacy owners to obtain closure under PADEP's ACT2, but must manage soils and groundwater on site per site covenants and deed restrictions.*
- *The facility is a RCRA Large Quantity Generator (LQG) under RCRA, and must comply with RCRA requirements for hazardous waste disposal.*
- *The facility is a Title V facility, and must comply with the Title V permit, which includes operating limits and work practice standards necessary for compliance.*
- *Wastewater and stormwater discharges from the site are subject to the requirements of the NPDES permit.*

Would any of the following have the potential to be impacted (directly or indirectly) by the proposed project?

- **No** Tribal lands or resources of Tribal interest and/or sensitivity
- **Yes** Environmental Justice (EJ) Populations *(EJ populations include minority, low-income, and Tribal populations)*
  - *(1)* TBD
  - *(2)* TBD
- **No** Historic, archeological, or cultural resources *(includes listed and eligible resources over 50 years old or of cultural significance)*
- **No** Areas having a special designation *(e.g., federal and state designated wilderness areas, national parks, national natural landmarks, wild and scenic rivers, state and federal wildlife refuges, and marine sanctuaries)*
- **Yes** Threatened or endangered species *(whether proposed or listed by state or Federal governments)*, including their habitat
  - (1) TBD
  - (2) TBD
- **No** Land resources *(e.g., prime farmland, unique farmland, or other farmland of statewide or local importance, tundra, rainforests)*
- **Yes**- Floodplains
  - (1) TBD
  - (2) TBD
  - (3) **Yes**- Wetlands
  - (4) TBD
  - (5) TBD
- **Yes**- Air quality *(indoor and/or outdoor)*
  - (1) TBD
  - (2) TBD
- ***Yes**- Greenhouse gas emissions*
  - (1) *TBD*
  - (2) *TBD*
- **Yes**- Water quality *(surface and/or ground water and/or special sources of water including sole source aquifers)*
  - *(1)* TBD
  - *(2)* TBD
- **No** - Ocean resources *(e.g., coral reefs)*
- **No** - Coastal zones
- **No**- Marine mammals or essential fish habitat
- Yes- Land use
  - *(1)* TBD
  - *(2)* TBD
- **No**— Socioeconomic conditions
- **No**- Sensitive receptors *(e.g., hospitals, schools, daycare facilities, elderly housing)*
- **No** - Navigable Airspace

- **No** - Transportation infrastructure

Please describe:

- **No**- any coordination or discussions that have been initiated or the plan to coordinate with state and/or federal agencies *(e.g., State Historic Preservation Office, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, Nuclear Regulatory Commission, etc.)*
- **No**- any coordination or discussions that have been initiated with any Tribal governments
- **No**- any issues that would generate public controversy regarding proposed project
- **No** (Note: The Monroe Energy Refinery site already is a permitted operating facility with historical existing studies)- any studies, reviews, and/or plans that have been completed for the proposed project *(e.g., environmental site assessments, waste management plans, health and safety plans, cultural resource surveys, identification of prime or unique farmland, wildlife surveys, etc.)*
- **Yes** – the proposed projects (H2 Plant and SAF are to reduce GHG via the new sustainable aviation fuels (SAF) being produced at the site for global utilization for airplanes as well as the future (H2 end use) replacement of burning natural/refinery fuel gas: hydrocarbons with H2 to reduce CO2 globally.
  any environmental considerations and/or mitigation strategies that have been incorporated into the proposed project *(e.g., measures to reduce and/or avoid greenhouse gas emissions, and/or impacts to cultural resources, historic properties, state or federally protected species, wetlands, floodplains, traffic, ambient noise, etc.)*
- **No**- any discussions with affected communities

Addendum: Question # 5
Monroe Energy LLC: Refinery: 4101 Post Rd, Marcus Hook, PA 19061

- SMR site - new H2 Plant
- Isocracker Unit – New SAF (Sustainable Aviation Fuels) Unit


SMR Site
Piperack at SMR ~24ftH
Isocracker Unit
FCC Reactor to sit here until outage
Bridge weight limited
Potential for Water Access


Soil Re-Use Pile
Isocracker Unit
SMR Site

ENVIRONMENTAL CONSIDERATIONS SUMMARY
PBF ENERGY

Please provide a brief summary of the proposed project. *Describe proposed activities (not goals and objectives) and specify if this project is part of a larger project or connected to another project.*

PBF is evaluating a comprehensive Delaware City Clean Hydrogen Hub concept (DCH2) that would be built on 2,500 acres of vacant land in New Castle County, DE, owned by DCRC. The scope and scale of the potential DCH2 project includes (i) generating 350 MW of renewable electricity primarily from solar power and potentially wind and hydropower; (ii) treatment and reuse of refinery gray water (WWTP effluent); (iii) production of 50,000 MT/year (137 MT/d) of clean hydrogen via electrolysis; (iv) the development of 10 million square feet of distribution warehouse space, offices and labs; (v) hydrogen compression, storage, and vehicle/transportation loading facilities. The potential project is expected to be undertaken in several phases, with the first phase being the construction of 180MW of electrolyzers, supporting utilities, and loading facilities.

To support other hydrogen end-users in the region, PBF further envisions building a 12-inch hydrogen pipeline, capable of carrying 63 MMSCFD (150 MT/d) from DCH2 to the greater Philadelphia area to support transportation, power generation, industrial and commercial uses of clean hydrogen.

Is there ongoing or anticipated federal government involvement in any aspect of this project (e.g., funding, permitting, technical assistance, project located on federally administered land)? *If "yes," please list the agency and describe the nature of the involvement.*

PBF expects the federal government may be involved via grant funds administered by the Department of Energy, clean hydrogen tax credits production tax credits, and permitting associated with the projects. Permitting agencies on the pipeline project are expected to include the US Army Corps of Engineers, US Pipeline and Hazardous Materials Administration (PHMSA), National Oceanic and Atmospheric Administration (NOAA) and the US Fish and Wildlife Service. Further evaluation on permitting will be determined evaluated in due course.

Is the project fully defined (i.e., all sites and activities are known)? *If "no", please describe the sites and/or activities/tasks that are yet to be defined.*

The project is not yet fully defined. Preliminary engineering and development have taken place on both the hydrogen generation and pipeline project, with an estimated 5% level of project definition.

All property for the hydrogen generation project is currently owned and controlled by PBF. PBF has preliminarily defined the plot space, connections, and modifications to the existing land on its site for this project.

The pipeline project has evaluated potential routings, possible right of way requirements, and crossing considerations for roads and waterways.

Complete the table below for each location where proposed project activities would take place:

Proposed location (physical address or coordinates)	**Setting of the proposed location (e.g., urban, industrial, suburban, agricultural, university campus, manufacturing facility, etc.) and the current condition or use of the site**	**General description of the proposed activities**	**Land administration (e.g., federal [specify BLM, USFS, etc.], Tribal, state, local, private)**
4550 Wrangle Hill Road, Delaware City, Delaware, 19706	Industrial facility; currently an operating petroleum refinery for the processing of crude oils into transportation fuels and useful byproducts	Production of hydrogen by electrolysis of water; treatment and reuse of refinery gray water (WWTP effluent); storage and loading of hydrogen; associated operations	Private property within state and local jurisdictions

Attach a map showing the location(s) of the proposed project, and a site layout map showing the proposed facilities and associated infrastructure. *(A GIS shapefile is preferrable, if available.)*

Please see attachments – Map of facility; plot plan for demo project; plot plan for full project; plot plan for Phase I project; Map with Additions and Tie-ins.

Describe new facilities to be constructed, any modifications of existing facilities, and any new infrastructure or facilities necessary for the construction or operation of the proposed project. *(e.g., access roads, laydown areas, off-site parking areas, railroad links, docks, water outfalls and intakes, pipelines, electrical transmission, waste treatment facilities, etc.)*

The potential new facilities include modifications to the existing property owned by Delaware City Refining Company.

Connections are envisioned to the existing refinery cooling water system, to re-use existing water. The potential hydrogen generation plant may include the following new facilities:

- Multiple proton exchange membrane (PEM) and/or solid-oxide electrolyzers

- A wastewater forwarding pump skid
- A water treatment system
- A demineralized water storage tank
- A demineralized water forwarding pump skid
- An electrode boiler system (if using solid-oxide electrolyzers)
- A compressed air system
- A nitrogen generation/storage system
- A closed cooling water system
- An oil-water separator
- A hydrogen blower unit (if using solid-oxide electrolyzers)
- A hydrogen dryer unit (if using solid-oxide electrolyzers)
- A hydrogen cooler unit (if using solid-oxide electrolyzers)
- A low pressure hydrogen gas compressor system (if using solid-oxide electrolyzers)
- A high pressure hydrogen gas compressor system
- A hydrogen bulk storage system
- Two truck loading stations
- Transformers
- Electrolyzer rectifiers
- A distributed control system and admin and control building
- An electrical enclosure

Some of the above equipment may not be required depending upon the final selection of electrolyzer technology. No new outfalls/intakes/docks, or waste treatment facilities are currently envisioned. Existing site laydown and parking areas will be used to the extent possible.

Identify and describe any existing, modifications to, or new permits, licenses, or authorizations that would be required to perform project activities. *(e.g., environmental permits, operating permits, or drilling permits)*

These details will be developed in due course.

Provide a brief description of the existing environmental burdens at the proposed project location(s) and surrounding areas, including those contributed to or exacerbated by existing facilities the H2Hub will leverage or modify. *Existing environmental burdens can be identified using available tools, such as DOE's Energy Justice Dashboard (beta) (https://www.energy.gov/diversity/energy-justice- dashboard-beta) or the U.S. Environmental Protection Agency's EJSCREEN (https://www.epa.gov/ejscreen).*

These details will be developed in due course. The proposed facility will be located at the same site as Delaware City Refining Company's existing Delaware City Refinery.

Would any of the following have the potential to be impacted (directly or indirectly) by the proposed project? *If "yes", provide a detailed description of: (1) the resources that could be* *affected, and (2) how project activities may affect those resources (including potential direct and indirect [visual, noise, etc.] impacts).*

a) Tribal lands or resources of Tribal interest and/or sensitivity – ***Cultural resource surveys would be conducted to evaluate potential colonial and tribal resources in areas considered for development.***
b) Environmental Justice (EJ) Populations *(EJ populations include minority, low-income, and Tribal populations)* – ***Not Expected***
c) Historic, archeological, or cultural resources *(includes listed and eligible resources over 50 years old or of cultural significance)* – ***Not Expected***
d) Areas having a special designation *(e.g., federal and state designated wilderness areas, national parks, national natural landmarks, wild and scenic rivers, state and federal wildlife refuges, and marine sanctuaries)* – ***Not Expected***
e) Threatened or endangered species *(whether proposed or listed by state or Federal governments)*, including their habitat – ***Habitat evaluations would be conducted for Atlantic and Shortnose Sturgeon, Bog turtles, American Bald Eagles and Blue Herons.***
f) Land resources *(e.g., prime farmland, unique farmland, or other farmland of statewide or local importance, tundra, rainforests)* - ***Some aspects of the project could be developed on properties owned by the refinery that are leased for farming.***
g) Floodplains – ***Not Expected***
h) Wetlands – ***Wetlands delineation and/or assessment studies have been undertaken on the existing properties and will be considered in the overall further development of the potential projects to avoid or minimize impacts.***
i) Air quality *(indoor and/or outdoor)* – ***Not Expected***
j) *Greenhouse gas emissions* – ***use of the manufactured hydrogen is expected to reduce greenhouse gas emissions. Electrical power for the electrolyzers is expected to be provided by renewable energy sources.***
k) Water quality *(surface and/or ground water and/or special sources of water including sole source aquifers)* – ***Not Expected***
l) Ocean resources *(e.g., coral reefs)* – ***Not Expected***
m) Coastal zones – ***The existing facility and proposed projects are located in the Delaware Coastal Zone. Coastal zone impacts would be evaluated by DNREC following submit of a request for status decision.***

n) Marine mammals or essential fish habitat – ***The Delaware River is considered critical habitat for Atlantic and Shortnose Sturgeon.***
o) Land use – ***Not Expected***
p) Socioeconomic conditions - ***Generally expected to be improved via provision of temporary and permanent jobs, attraction of new business.***
q) Sensitive receptors *(e.g., hospitals, schools, daycare facilities, elderly housing)* - ***Two elementatary schools are located nearby but impacts are not expected***
r) Navigable Airspace - **Not Expected**
s) Transportation infrastructure – ***Transportation impacts of the project will be evaluated.***

Please describe:

- any coordination or discussions that have been initiated or the plan to coordinate with state and/or federal agencies (e.g., State Historic Preservation Office, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, Nuclear Regulatory Commission, etc.)

PBF plans to coordinate and discuss with appropriate state of Delaware and federal agencies throughout the potential projects.

- any coordination or discussions that have been initiated with any Tribal governments

Not expected.

- any issues that would generate public controversy regarding proposed project

- any studies, reviews, and/or plans that have been completed for the proposed project (e.g., environmental site assessments, waste management plans, health and safety plans, cultural resource surveys, identification of prime or unique farmland, wildlife surveys, etc.)

PBF has undertaken various site surveys, wetlands delineation, and wetlands assessment reports on the subject properties.

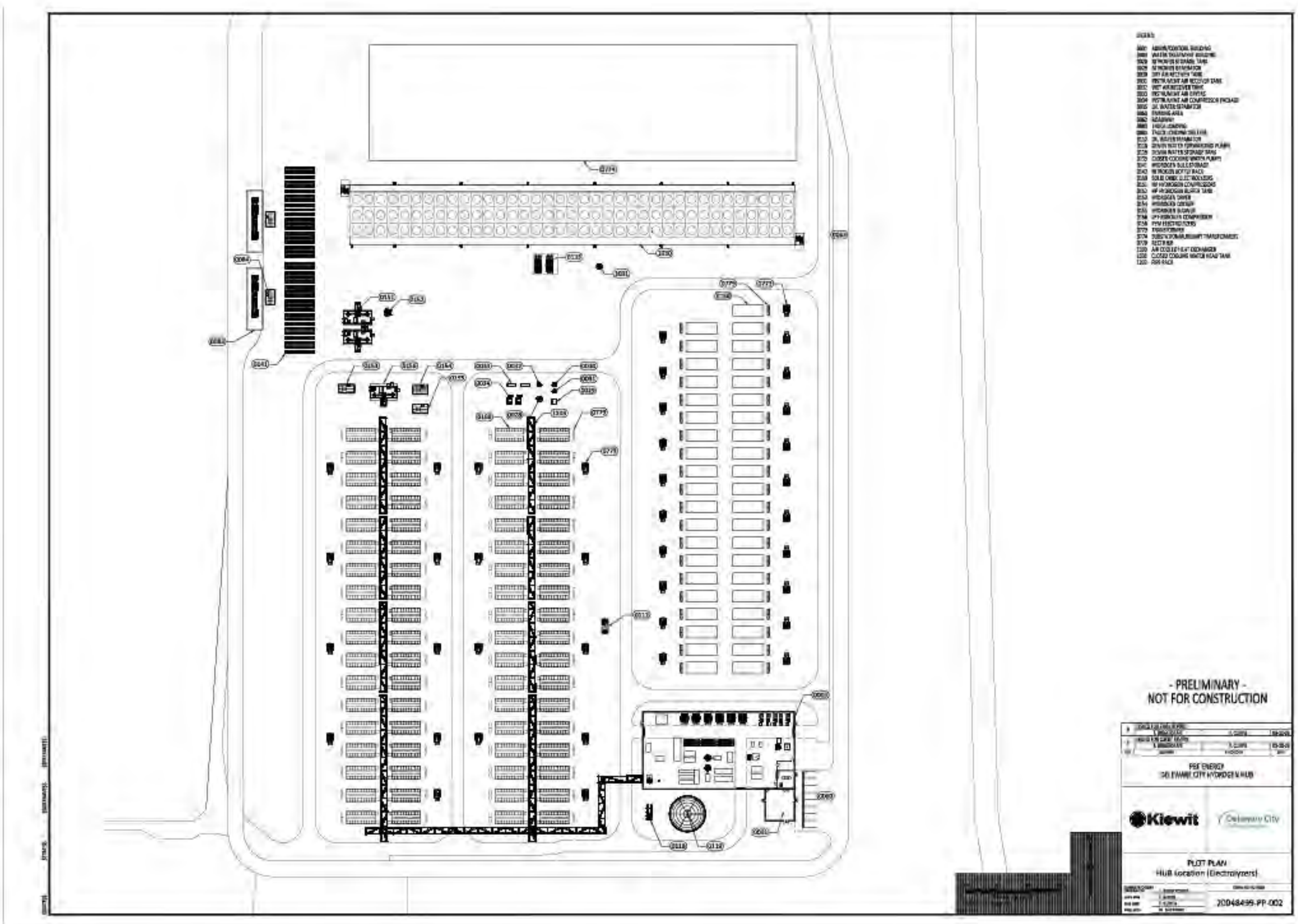
- any environmental considerations and/or mitigation strategies that have been incorporated into the proposed project (e.g., measures to reduce and/or avoid greenhouse gas emissions, and/or impacts to cultural resources, historic properties, state or federally protected species, wetlands, floodplains, traffic, ambient noise, etc.)

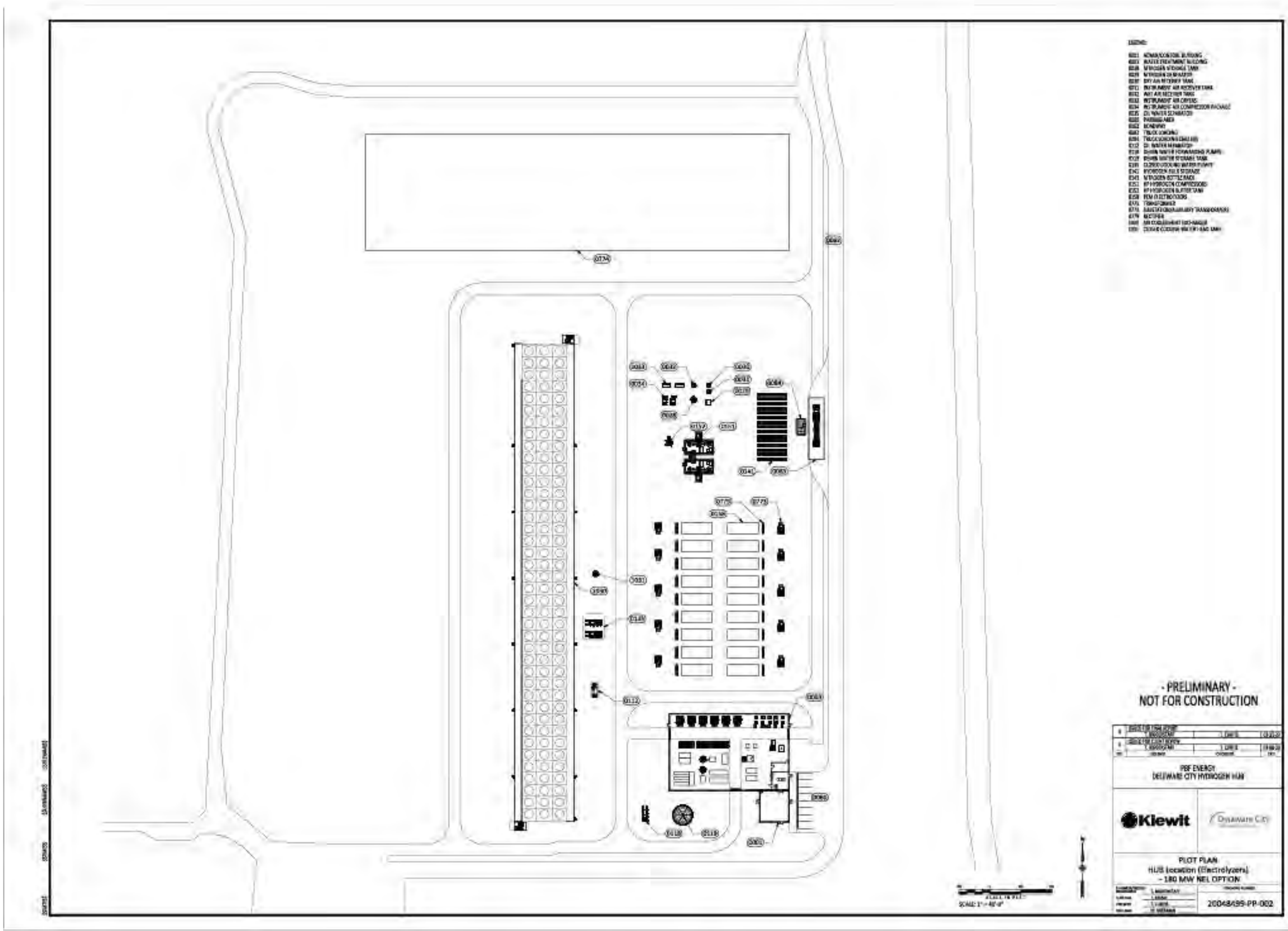
The purpose of the project is to produce green Hydrogen. Hydrogen will be produced via the electrolysis of water using renewable energy sources (wind turbines, solar panels and tidal.) Consideration of impacts and mitigation strategies for cultural resources, historic properties, state or federally protected species, wetlands, floodplains, traffic, ambient noise will be incorporated into the project.

- any discussions with affected communities

PBF has begun outreach and discussion with the surrounding and interested state and local government officials, communities and organizations.


Red Lion
Wrangle Hill
- PRELIMINARY -
NOT FOR CONSTRUCTION
PBF ENERGY
DELEWARE CITY HYDROGEN HUB
Delaware City
SITE PLAN
2004849 9-SP-001


- PRELIMINARY -
NOT FOR CONSTRUCTION
Kiewit
PLOT PLAN
HUB Location (Electrolyzers)
20048499-PP-002


- PRELIMINARY -
NOT FOR CONSTRUCTION
PBF ENERGY
DELAWARE CITY HYDROGEN HUB
Kiewit
PLOT PLAN
HUB Location (Electrolyzers)
- 180 MW NEL OPTION
20048/199-PP-002

ENVIRONMENTAL CONSIDERATIONS SUMMARY
PGW

Please provide a brief summary of the proposed project. *Describe proposed activities (not goals and objectives) and specify if this project is part of a larger project or connected to another project.*

PGW intends to facilitate the development of local hydrogen production in Philadelphia, for local distribution and end-uses in order to reduce local emissions. Carbon intensity of production and affordability are PGW's two primary evaluation criteria in selecting hydrogen technologies. Our approach is based on an unbiased, objective evaluation of the most practical and effective manner for reducing emissions today while also developing these nascent markets for long-term growth.

Based on that evaluation, PGW is pursuing an "all of the above" two-phased strategy, including the development of two hydrogen production facilities utilizing a mix of technologies to best address affordability and environmental impacts, including: Steam Methane Reforming ("SMR") utilizing Renewable Natural Gas ("RNG") feedstock and carbon capture, followed by a larger electrolyzer facility utilizing renewable electricity.

PGW also intends to support the overall MACH2 hub's development of the most practical and cost-effective hydrogen distribution networks possible. To these ends, PGW will facilitate development of new dedicated hydrogen pipelines from (1) the proposed PGW production facilities to nearby end-uses and (2) the regional Inter-Refinery Pipeline's (IRPL) current terminus into PGW's Passyunk plant, where a gaseous hydrogen trailer loading facility will be developed for trucking distribution to other local Philadelphia end-users.

PGW is proposing to facilitate a Phase I project at its Richmond plant, utilizing the more mature and cost competitive SMR process. PGW is planning on utilizing Renewable Natural Gas ("RNG") feedstock to mitigate the project's full lifecycle emissions and qualify for the maximum hydrogen Production Tax Credit based on emissions. Furthermore, PGW is also including carbon capture technology in the proposed Phase I project, with the assumption that offtake markets will be developed by that time.

Based on our analysis, this proposed Phase I SMR approach is both the most affordable (in terms of hydrogen price-point) and sustainable (in terms of full life cycle carbon intensity) of the options practically available to us today. Grid electricity is currently the most carbon intensive form of hydrogen production, with a higher full lifecycle CO_2e carbon intensity than SMR. Large-scale new renewable power is expected to increasingly come on-line in the years to come, but at this point presents a constraint in developing truly "green" hydrogen utilizing additional, deliverable renewable power. For now, the proposed Phase I SMR approach incorporating RNG feedstock and carbon capture technology provides a cost-effective Phase I solution while still mitigating project emission.

We acknowledge the rapidly evolving technologies and overall industry, and are intentionally building in flexibility, allowing future pivots as better options for further reducing carbon intensity become practically feasible and cost competitive. As described further below, PGW will continue refining its analyses and proposed project between this DOE CleanH2 Hubs submission and the expected award notifications. If alternate Phase I approaches, specifically electrolysis utilizing renewable power, are feasible and better address the carbon intensity and affordability evaluation criteria, then PGW will modify its Phase I approach. Regardless, PGW will increasingly mitigate project emissions going forward into Phase II as technologies and markets continue developing.

The Phase I project is currently planned as a 7.5 tons per day ("tpd") SMR production facility at PGW's Richmond Plant, selected and sized to match full-scale demand of targeted nearby end-users, Tioga Marine Terminal and the Philadelphia Municipal Fleet's Area 5 location, allowing for short-distance direct distribution pipelines. This approach is intended to minimize the need for and costs of longer-distance distribution, and maximize PGW current assets of existing real estate, energy infrastructure experience, and rights-of-way within the City of Philadelphia.

The Phase I project will also include the construction of a new dedicated hydrogen pipeline extending the existing IRPL from its current terminus into PGW's Passyunk plant. Gaseous hydrogen storage and trailer loading facilities will be developed at the Passyunk plant to provide local distribution the last few miles to Philadelphia hydrogen end-users from the large hydrogen production facilities upstream on the IRPL. While the IRPL extension and initial trailer loading facilities would begin with Phase I, the full-scale trailer loading facilities would likely be developed in several stages to match growing local hydrogen off-take markets over time.

PGW intends to pursue a Phase II project to facilitate additional hydrogen production capacity as new end-use loads come on-line and scale. As of now, Phase II would be an electrolyzer production facility utilizing renewable electricity, based on the expectation that new large-scale renewable power will be more readily available several years in the future. Again, these expectations will be revisited closer to project decision-points, through the same lens as the Phase I evaluation: prioritizing the best practically feasible balance of both affordability and environmental impacts.

The Phase II project is currently planned as a 15 tpd electrolyzer production facility at PGW's Passyunk Plant. PGW selected this site due to its proximity to other large transportation fleets, including the SEPTA Southern Depot and potential future nearby end-use applications. Phase II therefore would also include the construction of additional dedicated hydrogen distribution pipelines from the PGW production facilities to additional nearby hydrogen end-users as new load continues to scale.

For the Phase II project, PGW would target sourcing renewable electricity. To these ends, PGW is evaluating the development of a potential solar facility on its real estate. Greater renewable power generation capacity would be needed to address the electrolyzer's full electric demand.

PGW intends to collaborate with other local partners in pursuing a regional solar power purchase agreement ("PPA") to address its hydrogen production's full electric demand.

These two production facilities will support refueling stations to be constructed at the Philadelphia Municipal Fleet station in Richmond, and the Tioga Marine Facility, located in Richmond, as well.

Is there ongoing or anticipated federal government involvement in any aspect of this project (e.g., funding, permitting, technical assistance, project located on federally administered land)? *If "yes," please list the agency and describe the nature of the involvement.*

No.

Is the project fully defined (i.e., all sites and activities are known)? *If "no", please describe the sites and/or activities/tasks that are yet to be defined.*

They are defined to the point of 5% engineering and design. As noted above, we have included some flexibility in our planned approach to pivot to more cost-competitive and less carbon intensive hydrogen production processes between grant submission and potential award notifications.

Complete the table below for each location where proposed project activities would take place:

Proposed location (physical address or coordinates)	Setting of the proposed location (e.g., urban, industrial, suburban, agricultural, university campus, manufacturing facility, etc.) and the current condition or use of the site	General description of the proposed activities	Land administration (e.g., federal [specify BLM, USFS, etc.], Tribal, state, local, private)
PGW Richmond	Urban, industrial, currently in use for industrial activities	Construction of hydrogen production facility and ongoing operation, including distribution	
PGW Passyunk	Urban, industrial, currently in use for industrial activities	Extension of IRPL hydrogen distribution pipeline and construction of gaseous hydrogen trailer loading facilities for local trucking distribution Construction of production facility	

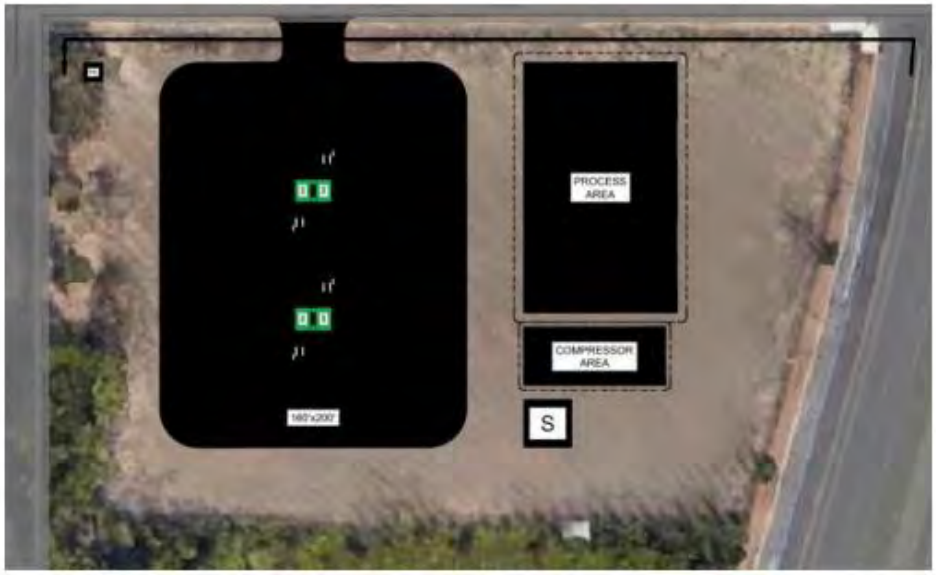
		and ongoing operation, including distribution	
Tioga Marine	Urban, industrial, currently in use for industrial activities	Construction of hydrogen storage, compression, and vehicle dispensing facilities Procurement of new hydrogen vehicles Ongoing operation, including distribution	
Philadelphia Municipal Fleet	Urban, industrial, currently in use for industrial activities	Construction of hydrogen storage, compression, and vehicle dispensing facilities Procurement of new hydrogen vehicles Ongoing operation, including distribution	

Attach a map showing the location(s) of the proposed project, and a site layout map showing the proposed facilities and associated infrastructure. *(A GIS shapefile is preferrable, if available.)*

PGW Plant Locations

PGW Richmond Plant Overall Site Plan

PGW Richmond Plant Phase I SMR project site plan



PGW Passyunk Plant Overall Site Plan

PGW Passyunk Plant Phase II PEM electrolyzer project site plan

Describe new facilities to be constructed, any modifications of existing facilities, and any new infrastructure or facilities necessary for the construction or operation of the proposed project. *(e.g., access roads, laydown areas, off-site parking areas, railroad links, docks, water outfalls and intakes, pipelines, electrical transmission, waste treatment facilities, etc.)*

Compression: This analysis assumes a diaphragm compressor, actual compression requirements will depend upon production pressure and target storage pressure, which will be finalized later in design.

Storage: On-site hydrogen storage is necessary to insulate the production from fluctuating demand, allowing for maximum utilization of the installed equipment. The amount of storage required will depend on the specific supply and demand profiles, which are subject to change as the hydrogen economy develops. From a practical standpoint, 3 days is useful as it allows the weekends to be bridged but storage can get quite expensive. For the purposes of this analysis, 1 day storage at a price of $1,000/kg for stationary storage is used. Periodic inspections of storage vessels and relief devices are required but they are considered maintenance free for the purposes of this analysis. Any energy usage related to storage is captured by the compressors.

Utilities:

- Electricity: Based on a review of available power at both sites, there is no capacity for additional electrical demands at the Richmond facility. The Passyunk facility could be upgraded to accommodate SMR systems, at least for Phase I production levels, by upgrading the service cables supplying the facility, but additional work would be required to support sufficient electrolyzer capacity. For simplicity, it is assumed a new service would be brought in at the locally available 13.2 kV. This involves two parts: PECO bringing in power to the site, and medium voltage switchgear installed as a part of this project between the utility service and the process equipment. Electrolyzers can take 13.2 kV input directly, but auxiliary equipment and SMR systems require 480 V input. The costs of the associated switchgear will vary with load, but it is not linear – the high load electrolyzer cases may only be 5 times as much as the low load SMR conditions.

- Natural Gas: Both the Richmond and Passyunk sites are gas handling sites already, there is sufficient gas supply present on-site for use. Some work for connections would be needed, but it should not be a significant cost compared to other aspects of this project.

- Potable Water: New potable water service would need to be brought into each site. With the highest capacity case only at 54 GPM, it is not anticipated to incur significant costs.

Hydrogen Distribution: PGW selected the Richmond site for Phase I and the Passyunk site for Phase II due to their relative proximity to prospective end users. The Tioga Marine and the Municipal Fleet sites area share a common border and are approximately one mile away from Richmond. The SEPTA Southern Depot and other potential future end-users are within a similar distance from Passyunk. The new approximately 2 miles distribution pipeline extending from the current IRPL terminus Into PGW's Passyunk Plant will support new gaseous trailer loading facilities to provide local trucking distribution to the City of Philadelphia

Phase I Carbon Capture: Carbon capture, utilization, and storage ("CCUS") captures CO2 at the point of production (or direct from ambient air) as a means of reducing global CO2 levels. This captured carbon can be used for industrial processes (enhanced oil recovery, urea, methanol, beverage carbonation, construction) or sequestered through permanent storage (underground caverns, enhanced oil recovery). This technology is most effective for treating high concentrations, like in SMR systems where there is little dilution air present. However, there are a few challenges with this technology in its current state:

- Carbon capture systems are capital intensive and logistically complex. Effective carbon capture systems require separation/purification, compression/liquefaction, and transportation of the captured CO2. There are few industrial users that require the captured CO2 at scale, so oftentimes there is no economic value of the captured CO2; costs for permanent underground storage can reach $20-50/ton, with another $50/ton required for the treatment and transportation. This can eclipse any available credits for sequestration.

- It is an energy intensive process. Our analysis estimates a conservative 0.3 kWh/kg CO2 number assuming less purification is required for storage. Even this conservative number will require substantial electric requirements; if paired with current grid electricity from the RFCE region, then the electric demands offset roughly 10% of the potential carbon intensity reduction from the capture. In more carbon intensive regions of the country, this rate would exceed 20%.

- Historically, carbon capture technologies do not have a high success rate. High profile projects have captured well below their rated capacities throughout the US and Canada or failed altogether. There are many additional largescale CCUS projects set to come online in the coming decades, so this may become more feasible in the future.

PGW will continue tracking CCUS technology and market developments and aggressively pursuing offtake opportunities for incorporation into the proposed Phase I SMR facility.

Passyunk Trailer Loading: PGW is proposing to facilitate the development of gaseous hydrogen trailer loading facilities at its Passyunk Plant, to provide the last few miles of trucking distribution to local hydrogen end-users from hydrogen production facilities upstream on the IRPL. At this time, PGW anticipates the development of trailer loading facilities capable of processing approximately 22 tpd H2 at full-scale, likely developed in several stages to match growing local hydrogen off-take markets over time. This full-scale development is forecasted to cost approximately $48.7 million in total capital expenses.

Phase II Solar Power: PGW had previously evaluated the potential feasibility of developing solar systems at its two gas plants. These two systems, listed below, have the potential to provide up to 1.18 MW in capacity. PGW intends to collaborate with other local partners in pursuing a solar PPA to address the remainder of its Phase II electrolyzer full electric demand. This solar study would need to be updated, including specific siting based on the introduction of the proposed new hydrogen facilities.

PGW Passyunk Plant Potential PV Locations

PGW Richmond Plant Potential PV Locations

Identify and describe any existing, modifications to, or new permits, licenses, or authorizations that would be required to perform project activities. *(e.g., environmental permits, operating permits, or drilling permits)*

The PGW Richmond Plant and Passyunk Plant both operate under air pollution operating permits administered by the Philadelphia Department of Health Air Management Services (AMS). The Richmond Plant operates as a major source of NOx under a Title V Operating Permit. The Passyunk Plant operates as a minor source of NOx under a Synthetic Minor Operating Permit. All PGW air pollution permits and licenses are managed by the Environmental Compliance Department.

The Steam Methane Reforming (SMR) project would likely have air emissions permitting implications which would require AMS installation permits, plan approval, and/or operating permit modifications. Based on emissions estimates provided by a potential vendor and Philadelphia's status as an ozone non-attainment area, nitrogen oxides (NOx) would be the most likely air pollutant to drive permitting. The SMR unit can be installed in a configuration uncontrolled for NOx or with selective catalytic reduction (SCR) to reduce NOx emissions. In an uncontrolled configuration, approximately 0.86 short tons of NOx are generated per 1,000 kg of hydrogen produced. Configured with SCR, the SMR system will generate approximately 0.097 short tons of NOx per 1,000 kg of hydrogen produced. For the proposed Phase I SMR project, these levels are expected to fall within the synthetic minor permit.

PGW is also subject to the mandatory Greenhouse Gas Reporting Program (GHGRP) administered by the United States Environmental Protection Agency (USEPA) under Subpart W and Subpart NN. Based on the projected CO2e emissions from the SMR unit, Subpart P may also be triggered which would require additional annual reporting. The threshold for mandatory reporting is 25,000 metric tons per year. Based on manufacturer provided information, the SMR system generates approximately 3,790 metric tons of CO2e per 1,000 kg of hydrogen produced for a total of approximately 30,320 metric tons of CO2e per year. These emissions would be reduced by nearly 70% by the proposed CCUS approach reducing 91 tpd of CO2 emissions down to 28 tpd of CO2 emissions utilizing CCUS.

Provide a brief description of the existing environmental burdens at the proposed project location(s) and surrounding areas, including those contributed to or exacerbated by existing facilities the H2Hub will leverage or modify. *Existing environmental burdens can be identified using available tools, such as DOE's Energy Justice Dashboard (beta) (https://www.energy.gov/diversity/energy-justice-dashboard-beta) or the U.S. Environmental Protection Agency's EJSCREEN (https://www.epa.gov/ejscreen).*

The PGW Richmond Plant and PGW Passyunk Plant are PGW facilities that have existed since the early 1900s, and as a result had historic releases of various constituents associated with site operations. PGW has enrolled the PGW Richmond Plant and PGW Passyunk Plant into the Commonwealth of Pennsylvania's site remediation program, known as the Pennsylvania Land Recycling and Environmental Remediation Standards Act ("Act 2"), 35 P.S. § 6026.101 et seq, to investigate and remediate the historic releases. The PGW Richmond Plant and PGW Passyunk Plant are currently going through the Act 2 process under the oversight of the Pennsylvania Department of Environmental Protection.

Would any of the following have the potential to be impacted (directly or indirectly) by the proposed project? *If "yes", provide a detailed description of: (1) the resources that could be affected, and (2) how project activities may affect those resources (including potential direct and indirect [visual, noise, etc.] impacts).*

- Tribal lands or resources of Tribal interest and/or sensitivity
- Environmental Justice (EJ) Populations *(EJ populations include minority, low-income, and Tribal populations)*

Philadelphia, well known as the largest poor city in the United States, has a poverty rate approaching 27%.[1] And the correlation between pollution burdens and urban lower socioeconomic status and racially marginalized groups in well documented. "[R]acial/ethnic minority populations were more than two times as likely than non-Hispanic white populations to live in a census block group with highest air pollution levels (above 90th percentile) on average".[2] And "absolute income-based exposure disparities were also 7.5 times larger on average in urban than in rural areas".[3] It is for those reasons and others that this project will ensure that more 40% of the benefit will flow to underserved, marginalized and overly burdened individuals in pursuit of the Justice40 Initiative. By transitioning at least three hundred diesel vehicles (including trash trucks, buses, etc.) emitting greenhouse gases and transitioning their refueling hubs located directly in some of the most severely located census blocks[4] to zero emissions vehicles over the next ten to twenty years, more than 40% of that improved air quality will flow to these underserved and marginalized communities.

- Historic, archeological, or cultural resources *(includes listed and eligible resources over 50 years old or of cultural significance)*
- Areas having a special designation *(e.g., federal and state designated wilderness areas, national parks, national natural landmarks, wild and scenic rivers, state and federal wildlife refuges, and marine sanctuaries)*
- Threatened or endangered species *(whether proposed or listed by state or Federal governments)*, including their habitat
- Land resources *(e.g., prime farmland, unique farmland, or other farmland of statewide or local importance, tundra, rainforests)*
- Floodplains
- Wetlands
- Air quality *(indoor and/or outdoor)*

As of now, Phase II would be an electrolyzer production facility (eliminating the need for natural gas feedstock) utilizing renewable electricity, based on the expectation that new large-scale renewable power will be more readily available several years in the future. For the Phase II

[1] EICHEL, LARRY, ET. AL, Philadelphia's Poor: Who they are, where they live, and how that has changed, p. 1, available at https://www.pewtrusts.org/-/media/assets/2017/11/pri_philadelphias_poor.pdf(last visited Mar. 29, 2023).

[2] LIU, JIAWEN, ET. AL, Disparities in Air Pollution Exposure in the United States by Race/Ethnicity and Income, 1990–2010, *Environmental Health Perspectives*, December 2021 127005-1, 12

[3] *Id*.

[4] Justice40 by Number of Categories Map November 2022 (Philadelphia, PA) available at https://www.arcgis.com/apps/mapviewer/index.html?webmap=ee9ddbc95520442482cd511f9170663a (last visited March 29, 2023).

project, PGW would target sourcing renewable electricity. To these ends, PGW is evaluating the development of a potential solar facility on its real estate.

- *Greenhouse gas emissions*

In Phase I, PGW is planning on utilizing Renewable Natural Gas ("RNG") feedstock to mitigate the project's full lifecycle emissions and qualify for the maximum hydrogen Production Tax Credit based on emissions. Furthermore, PGW is also including carbon capture technology in the proposed Phase I project, with the assumption that offtake markets will be developed by that time.

- Water quality *(surface and/or ground water and/or special sources of water including sole source aquifers)*
- Ocean resources *(e.g., coral reefs)*
- Coastal zones
- Marine mammals or essential fish habitat
- Land use
- Socioeconomic conditions
- Sensitive receptors *(e.g., hospitals, schools, daycare facilities, elderly housing)*
- Navigable Airspace
- Transportation infrastructure

Please describe:

- any coordination or discussions that have been initiated or the plan to coordinate with state and/or federal agencies *(e.g., State Historic Preservation Office, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, Nuclear Regulatory Commission, etc.)*
- any coordination or discussions that have been initiated with any Tribal governments
- any issues that would generate public controversy regarding proposed project
- any studies, reviews, and/or plans that have been completed for the proposed project *(e.g., environmental site assessments, waste management plans, health and safety plans, cultural resource surveys, identification of prime or unique farmland, wildlife surveys, etc.)*
- any environmental considerations and/or mitigation strategies that have been incorporated into the proposed project *(e.g., measures to reduce and/or avoid greenhouse gas emissions, and/or impacts to cultural resources, historic properties, state or federally protected species, wetlands, floodplains, traffic, ambient noise, etc.)*

In Phase I, PGW is planning on utilizing Renewable Natural Gas ("RNG") feedstock to mitigate the project's full lifecycle emissions and qualify for the maximum hydrogen Production Tax Credit based on emissions. Furthermore, PGW is also including carbon capture technology in the proposed Phase I project, with the assumption that offtake markets will be developed by that time.

As of now, Phase II would be an electrolyzer production facility (eliminating the need for natural gas feedstock) utilizing renewable electricity, based on the expectation that new large-scale renewable power will be more readily available several years in the future. For the Phase II project, PGW would target sourcing renewable electricity. To these ends, PGW is evaluating the development of a potential solar facility on its real estate.

- any discussions with affected communities

Location(s) of Work Documentation

DE-FOA-0002779

Control Number: 2779-1593

Prime Applicant/ Team Member	Address	City	State	Nine Digit Zip Code (ZIP+4)
Chesapeake Utilities	NJ Route 13	Georgetown	DE	19901
Croda	315 Cherry Lane	New Castle	DE	19720
Delaware Area Rapid Transit (DART)	119 Lower Beech Street	Wilmington	DE	19805
Dupont Experimental Station	200 Powder Mill Road, Building 322	Wilmington	DE	19803
Enbridge	501 Coolidge Street	South Plainfield	NJ	07080
Hilco - Bellwether District	3144 Passyunk Avenue	Philadelphia	PA	19145
Holtec - Oyster Creek	741 US Route 9	Forked River	NJ	08731
Holtec - Salem	Lower Alloways Creek	Salem	NJ	08079
Messer Industrial Gases	6000 Philadelphia Pike / 10 Highland Avenue	Claymont / Chester	DE / PA	19073 / 19013
Monroe Energy - Boilers	4101 Post Road	Trainer	PA	19061
PBF Energy - Delaware City Refinery	403 Hamburg Corner River Road	New Castle	DE	19720
Philadelphia Gas Works (PGW) - Electrolysis	3100 W. Passyunk Avenue	Philadelphia	PA	19145
Philadelphia Gas Works (PGW) - SMR	3100 E. Venango Street	Philadelphia	PA	19134
PSEG - South Jersey	TBD	Rapauno	NJ	08027
SEPTA	1234 Market Street	Philadelphia	PA	19107
sHYp - Phase 4	200 Powder Mill Road	Wilmington	DE	19806
University of Delaware	210 South College Avenue	Newark	DE	19716
Versogen	TBD	Marcus Hook / Twin Oaks	PA	19803

DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C.1352

OMB Number: 4040-0013
Expiration Date: 02/28/2025

1. * Type of Federal Action:

- [ ] a. contract
- [x] b. grant
- [ ] c. cooperative agreement
- [ ] d. loan
- [ ] e. loan guarantee
- [ ] f. loan insurance

2. * Status of Federal Action:

- [ ] a. bid/offer/application
- [x] b. initial award
- [ ] c. post-award

3. * Report Type:

- [x] a. initial filing
- [ ] b. material change

4. Name and Address of Reporting Entity:

[x] Prime [x] SubAwardee

* Name: Chesapeake Utilities
* Street 1: 500 Energy Lane
Street 2:
* City: Dover
State: DE
Zip: 19904

Congressional District, if known:

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

6. * Federal Department/Agency:

US Department of Energy - Office of Clean Energy Demonstrations

7. * Federal Program Name/Description:

FOA-0002779: Regional Clean Hydrogen Hubs

CFDA Number, *if applicable:* 81.255

8. Federal Action Number, *if known:*

9. Award Amount, *if known:*

$

10. a. Name and Address of Lobbying Registrant:

Prefix:
* First Name: N/A
Middle Name:
* Last Name: N/A
Suffix:
* Street 1:
Street 2:
* City:
State:
Zip:

b. Individual Performing Services (including address if different from No. 10a)

Prefix:
* First Name: N/A
Middle Name:
* Last Name: N/A
Suffix:
* Street 1:
Street 2:
* City:
State:
Zip:

11. Information requested through this form is authorized by title 31 U.S.C. section 1352. This disclosure of lobbying activities is a material representation of fact upon which reliance was placed by the tier above when the transaction was made or entered into. This disclosure is required pursuant to 31 U.S.C. 1352. This information will be reported to the Congress semi-annually and will be available for public inspection. Any person who fails to file the required disclosure shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

*** Signature:** Completed on submission to Grants.gov

***Name:**
Prefix:
* First Name: Shane
Middle Name:
* Last Name: Breakie
Suffix:

Title: Vice President Sustainability and Organic Growth
Telephone No.:
Date: Completed on submission to Grants.gov

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DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C.1352

OMB Number: 4040-0013
Expiration Date: 02/28/2025

1. * Type of Federal Action:
- [ ] a. contract
- [x] b. grant
- [ ] c. cooperative agreement
- [ ] d. loan
- [ ] e. loan guarantee
- [ ] f. loan insurance

2. * Status of Federal Action:
- [ ] a. bid/offer/application
- [x] b. initial award
- [ ] c. post-award

3. * Report Type:
- [x] a. initial filing
- [ ] b. material change

4. Name and Address of Reporting Entity:

[x] Prime [ ] SubAwardee

* Name: DuPont Experimental Station
* Street 1: 200 Powder Mill Rd
Street 2:
* City: Wilmington
State: De
Zip: 19803
Congressional District, if known:

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

6. * Federal Department/Agency: Department of Energy

7. * Federal Program Name/Description:

CFDA Number, *if applicable:*

8. Federal Action Number, *if known:*

9. Award Amount, *if known:* $

10. a. Name and Address of Lobbying Registrant:

Prefix:
* First Name: Vere
Middle Name:
* Last Name: Archibald
Suffix:
* Street 1:
Street 2:
* City:
State:
Zip:

b. Individual Performing Services (including address if different from No. 10a)

Prefix:
* First Name:
Middle Name:
* Last Name:
Suffix:
* Street 1:
Street 2:
* City:
State:
Zip:

11. Information requested through this form is authorized by title 31 U.S.C. section 1352. This disclosure of lobbying activities is a material representation of fact upon which reliance was placed by the tier above when the transaction was made or entered into. This disclosure is required pursuant to 31 U.S.C. 1352. This information will be reported to the Congress semi-annually and will be available for public inspection. Any person who fails to file the required disclosure shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

*** Signature:** Completed on submission to Grants.gov

***Name:** Prefix: * First Name: Middle Name:
* Last Name: Suffix:

Title: **Telephone No.:** **Date:** Completed on submission to Grants.gov

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DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C.1352

OMB Number: 4040-0013
Expiration Date: 02/28/2025

1. * Type of Federal Action:

- [ ] a. contract
- [X] b. grant
- [ ] c. cooperative agreement
- [ ] d. loan
- [ ] e. loan guarantee
- [ ] f. loan insurance

2. * Status of Federal Action:

- [ ] a. bid/offer/application
- [X] b. initial award
- [ ] c. post-award

3. * Report Type:

- [X] a. initial filing
- [ ] b. material change

4. Name and Address of Reporting Entity:

[ ] Prime [X] SubAwardee Tier if known:

* Name: Enbridge (U.S.) Inc

* Street 1: 915 N Eldridge Pkwy, Ste 1100 Street 2:

* City: Houston State: TX: Texas Zip: 77079

Congressional District, if known: TX 38

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

* Name: City of Philadelphia

* Street 1: Philadelphia Department of Labor Street 2: City Hall; Room 205

* City: Philadelphia State: PA: Pennsylvania Zip: 19107

Congressional District, if known: PA 03

6. * Federal Department/Agency:

U.S. Department of Energy

7. * Federal Program Name/Description:

Regional Clean Hydrogen Hubs

CFDA Number, *if applicable:* DE-FOA-0002779

8. Federal Action Number, *if known:*

9. Award Amount, *if known:*

$

10. a. Name and Address of Lobbying Registrant:

Prefix: * First Name: Peter Middle Name:

* Last Name: Sheffield Suffix:

* Street 1: 20 F Street, NW Street 2:

* City: Washington State: DC: District of Columbia Zip: 20001

b. Individual Performing Services (including address if different from No. 10a)

Prefix: * First Name: Peter Middle Name:

* Last Name: Sheffield Suffix:

* Street 1: Street 2:

* City: State: Zip:

11. Information requested through this form is authorized by title 31 U.S.C. section 1352. This disclosure of lobbying activities is a material representation of fact upon which reliance was placed by the tier above when the transaction was made or entered into. This disclosure is required pursuant to 31 U.S.C. 1352. This information will be reported to the Congress semi-annually and will be available for public inspection. Any person who fails to file the required disclosure shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

*** Signature:**

***Name:** Prefix: * First Name: Peter Middle Name:

* Last Name: Sheffield Suffix:

Title: Vice Pres External Affairs, U.S. **Telephone No.:** 202-347-2053 **Date:** 3/30/23

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DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C.1352

OMB Number: 4040-0013
Expiration Date: 02/28/2025

1. * Type of Federal Action:

- [ ] a. contract
- [x] b. grant
- [ ] c. cooperative agreement
- [ ] d. loan
- [ ] e. loan guarantee
- [ ] f. loan insurance

2. * Status of Federal Action:

- [ ] a. bid/offer/application
- [x] b. initial award
- [ ] c. post-award

3. * Report Type:

- [x] a. initial filing
- [ ] b. material change

4. Name and Address of Reporting Entity:

- [ ] Prime
- [x] SubAwardee

** Name* Hilco Redevelopment Partners and/or Philadelphia Energy Solutions Refining and Marketing LLC

** Street 1* 2929 Arch Street *Street 2* Suite 1650

** City* Philadelphia *State* PA *Zip* 19104

Congressional District, if known: PA-03 & PA-05

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

Abovementioned entities are not engaged in direct lobbying activities for the federal program listed in section 7 at this time.

6. * Federal Department/Agency:

US Department of Energy - Office of Clean Energy Demonstrations

7. * Federal Program Name/Description:

FOA-0002779: Regional Clean Hydrogen Hubs

CFDA Number, *if applicable:* 81.255

8. Federal Action Number, *if known:*

9. Award Amount, *if known:*

$

10. a. Name and Address of Lobbying Registrant:

Prefix ** First Name* N/A *Middle Name*

** Last Name* *Suffix*

** Street 1* *Street 2*

** City* *State* *Zip*

b. Individual Performing Services (including address if different from No. 10a)

Prefix ** First Name* N/A *Middle Name*

** Last Name* *Suffix*

** Street 1* *Street 2*

** City* *State* *Zip*

11. Information requested through this form is authorized by title 31 U.S.C. section 1352. This disclosure of lobbying activities is a material representation of fact upon which reliance was placed by the tier above when the transaction was made or entered into. This disclosure is required pursuant to 31 U.S.C. 1352. This information will be reported to the Congress semi-annually and will be available for public inspection. Any person who fails to file the required disclosure shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

[redacted] [redacted]

[redacted] [redacted] [redacted] Amelia [redacted] Chasse

[redacted] Alcivar [redacted]

[redacted] EVP of Corporate Affairs [redacted]: [redacted]

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DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C.1352

OMB Number: 4040-0013
Expiration Date: 02/28/2025

1. * Type of Federal Action:

- [ ] a. contract
- [x] b. grant
- [ ] c. cooperative agreement
- [ ] d. loan
- [ ] e. loan guarantee
- [ ] f. loan insurance

2. * Status of Federal Action:

- [ ] a. bid/offer/application
- [x] b. initial award
- [ ] c. post-award

3. * Report Type:

- [x] a. initial filing
- [ ] b. material change

4. Name and Address of Reporting Entity:

[x] Prime [✓] SubAwardee

** Name* Holtec Government Services

** Street 1* 1 Holtec Blvd *Street 2*

** City* Camden *State* New Jersey *Zip* 08104

Congressional District, if known:

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

6. * Federal Department/Agency:

US Department of Energy - Office of Clean Energy Demonstrations

7. * Federal Program Name/Description:

FOA-0002779: Regional Clean Hydrogen Hubs

CFDA Number, *if applicable:* 81.255

8. Federal Action Number, *if known:*

9. Award Amount, *if known:*

$

10. a. Name and Address of Lobbying Registrant:

Prefix ** First Name* N/a *Middle Name*

** Last Name* *Suffix*

** Street 1* *Street 2*

** City* *State* *Zip*

b. Individual Performing Services (including address if different from No. 10a)

Prefix ** First Name* N/a *Middle Name*

** Last Name* *Suffix*

** Street 1* *Street 2*

** City* *State* *Zip*

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*** Signature:** Completed on submission to Grants.gov

***Name:** *Prefix* ** First Name* Myron *Middle Name*

** Last Name* Kaczmarsky *Suffix*

Title: Vice President **Telephone No.:** [redacted] **Date:** Completed on submission to Grants.gov

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DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C.1352

OMB Number: 4040-0013
Expiration Date: 02/28/2025

1. * Type of Federal Action:	**2. * Status of Federal Action:**	**3. * Report Type:**
☐ a. contract ☒ b. grant ☐ c. cooperative agreement ☐ d. loan ☐ e. loan guarantee ☐ f. loan insurance	☐ a. bid/offer/application ☒ b. initial award ☐ c. post-award	☒ a. initial filing ☐ b. material change

4. Name and Address of Reporting Entity:

☒ Prime ☐ SubAwardee

*Name: Mid-Atlantic Clean Hydrogen Hub, Inc.

*Street 1: 104 Grand Oaks Drive Street 2:

*City: Dover State: Delaware Zip: 19901

Congressional District, if known:

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

6. * Federal Department/Agency:

US Department of Energy - Office of Clean Energy Demonstrations

7. * Federal Program Name/Description:

FOA-0002779: Regional Clean Hydrogen Hubs

CFDA Number, *if applicable:* 81.255

8. Federal Action Number, *if known:*

9. Award Amount, *if known:*

$

10. a. Name and Address of Lobbying Registrant:

Prefix: *First Name: Not Applicable Middle Name:

*Last Name: Not Applicable Suffix:

*Street 1: Street 2:

*City: State: Zip:

b. Individual Performing Services (including address if different from No. 10a)

Prefix: *First Name: Not Applicable Middle Name:

*Last Name: Not Applicable Suffix:

*Street 1: Street 2:

*City: State: Zip:

11. Information requested through this form is authorized by title 31 U.S.C. section 1352. This disclosure of lobbying activities is a material representation of fact upon which reliance was placed by the tier above when the transaction was made or entered into. This disclosure is required pursuant to 31 U.S.C. 1352. This information will be reported to the Congress semi-annually and will be available for public inspection. Any person who fails to file the required disclosure shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

***Signature:** Completed on submission to Grants.gov

***Name:** Prefix: *First Name: Dora Middle Name:

*Last Name: Cheatham Suffix:

Title: Secretary/Treasurer **Telephone No.:** [redacted] **Date:** Completed on submission to Grants.gov

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DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C.1352

OMB Number: 4040-0013
Expiration Date: 02/28/2025

1. * Type of Federal Action:
- [ ] a. contract
- [x] b. grant
- [ ] c. cooperative agreement
- [ ] d. loan
- [ ] e. loan guarantee
- [ ] f. loan insurance

2. * Status of Federal Action:
- [ ] a. bid/offer/application
- [x] b. initial award
- [ ] c. post-award

3. * Report Type:
- [x] a. initial filing
- [ ] b. material change

4. Name and Address of Reporting Entity:

- [ ] Prime
- [x] SubAwardee

* Name: Messer Americas

* Street 1: 200 Somerset Corporate Blvd. Street 2:

* City: Bridgewater State: New Jersey Zip: 08807

Congressional District, if known: NJ-07

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

6. * Federal Department/Agency:

US Department of Energy - Office of Clean Energy Demonstrations

7. * Federal Program Name/Description:

FOA-0002779: Regional Clean Hydrogen Hubs

CFDA Number, *if applicable:* 81.255

8. Federal Action Number, *if known:*

9. Award Amount, *if known:*

$

10. a. Name and Address of Lobbying Registrant:

Prefix: * First Name: None Middle Name:

* Last Name: Suffix:

* Street 1: Street 2:

* City: State: Zip:

b. Individual Performing Services (including address if different from No. 10a)

Prefix: * First Name: None Middle Name:

* Last Name: Suffix:

* Street 1: Street 2:

* City: State: Zip:

11. Information requested through this form is authorized by title 31 U.S.C. section 1352. This disclosure of lobbying activities is a material representation of fact upon which reliance was placed by the tier above when the transaction was made or entered into. This disclosure is required pursuant to 31 U.S.C. 1352. This information will be reported to the Congress semi-annually and will be available for public inspection. Any person who fails to file the required disclosure shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

* **Signature:** Completed on submission to Grants.gov

***Name:** Prefix: * First Name: Michele Middle Name:

* Last Name: Long Suffix:

Title: Vice President, Communications, Americas **Telephone No.:** [redacted] : Completed on submission to Grants.gov

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DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C.1352

OMB Number: 4040-0013
Expiration Date: 02/28/2025

1. * Type of Federal Action:
- [ ] a. contract
- [x] b. grant
- [ ] c. cooperative agreement
- [ ] d. loan
- [ ] e. loan guarantee
- [ ] f. loan insurance

2. * Status of Federal Action:
- [ ] a. bid/offer/application
- [x] b. initial award
- [ ] c. post-award

3. * Report Type:
- [x] a. initial filing
- [ ] b. material change

4. Name and Address of Reporting Entity:

[x] Prime [✓] SubAwardee

* Name: Monroe Energy, LLC
* Street 1: 4101 Post Road
Street 2:
* City: Trainer
State: Pennsylvania
Zip: 19061
Congressional District, if known:

5.

Please be advised that at this time Monroe Energy, LLC does not anticipate engaging in any lobbying activities in relation to the Federal Program noted below. In the event Monroe Energy, LLC determines to engage in any lobbying activities in the future, it shall perform all such activity and make any necessary disclosures in accordance with the law.

6. * Federal Department/Agency:
US Department of Energy - Office of Clean Energy Demonstrations

7. * Federal Program Name/Description:
FOA-0002779: Regional Clean Hydrogen Hubs

CFDA Number, *if applicable:* 81.255

8. Federal Action Number, *if known:*

9. Award Amount, *if known:*
$

10. a. Name and Address of Lobbying Registrant:

Prefix:
* First Name: Not Applicable
Middle Name:
* Last Name: Not Applicable
Suffix:
* Street 1: Not Applicable
Street 2:
* City: Not Applicable
State:
Zip:

b. Individual Performing Services (including address if different from No. 10a)

Prefix:
* First Name: Not Applicable
Middle Name:
* Last Name: Not Applicable
Suffix:
* Street 1: Not Applicable
Street 2:
* City: Not Applicable
State: Not Applicable
Zip:

11. Information requested through this form is authorized by title 31 U.S.C. section 1352. This disclosure of lobbying activities is a material representation of fact upon which reliance was placed by the tier above when the transaction was made or entered into. This disclosure is required pursuant to 31 U.S.C. 1352. This information will be reported to the Congress semi-annually and will be available for public inspection. Any person who fails to file the required disclosure shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

*** Signature:** [signature]

***Name:** Prefix:
* First Name: Christopher
Middle Name:
* Last Name: Ruggiero
Suffix:

Title: SVP, General Counsel
Telephone No.: [redacted]ate: 3/29/23

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DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C.1352

Approved by OMB
4040-0013

1. * Type of Federal Action:

- [ ] a. contract
- [x] b. grant
- [ ] c. cooperative agreement
- [ ] d. loan
- [ ] e. loan guarantee
- [ ] f. loan insurance

2. * Status of Federal Action:

- [ ] a. bid/offer/application
- [x] b. initial award
- [ ] c. post-award

3. * Report Type:

- [x] a. initial filing
- [ ] b. material change

4. Name and Address of Reporting Entity:

[ ] Prime [x] SubAwardee Tier if known:

* Name: PBF Holding Company LLC

* Street 1: 1 Sylvan Way, 2nd Floor Street 2:

* City: Parsippany State: NJ: New Jersey Zip: 07054

Congressional District, if known:

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

* Name: Mid-Atlantic Clean Hydrogen Hub, Inc.

* Street 1: 104 Grand Oaks Drive Street 2:

* City: Dover State: DE: Delaware Zip: 19901

Congressional District, if known:

6. * Federal Department/Agency:

U.S. Department of Energy - OCED

7. * Federal Program Name/Description:

FOA-0002779: Regional Clean Hydrogen Hubs

CFDA Number, *if applicable:* 81.255

8. Federal Action Number, *if known:*

9. Award Amount, *if known:*

$

10. a. Name and Address of Lobbying Registrant:

Prefix: * First Name: Brendan Middle Name:

* Last Name: Williams Suffix:

* Street 1: 601 Pennsylvania Avenue, NW Street 2: Suite 900 South

* City: Washington State: DC: District of Columbia Zip: 20004

b. Individual Performing Services (including address if different from No. 10a)

Prefix: * First Name: Brendan Middle Name:

* Last Name: Williams Suffix:

* Street 1: 601 Pennsylvania Avenue, NW Street 2: Suite 900 South

* City: Washington State: DC: District of Columbia Zip: 20004

11. Information requested through this form is authorized by title 31 U.S.C. section 1352. This disclosure of lobbying activities is a material representation of fact upon which reliance was placed by the tier above when the transaction was made or entered into. This disclosure is required pursuant to 31 U.S.C. 1352. This information will be reported to the Congress semi-annually and will be available for public inspection. Any person who fails to file the required disclosure shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

*** Signature:**

***Name:** Prefix: * First Name: Brendan Middle Name:

* Last Name: Williams Suffix:

Title: **Telephone** [redacted]**ate:** 04/05/2023

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DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C.1352

OMB Number: 4040-0013
Expiration Date: 02/28/2025

1. * Type of Federal Action:
- [ ] a. contract
- [x] b. grant
- [ ] c. cooperative agreement
- [ ] d. loan
- [ ] e. loan guarantee
- [ ] f. loan insurance

2. * Status of Federal Action:
- [ ] a. bid/offer/application
- [x] b. initial award
- [ ] c. post-award

3. * Report Type:
- [x] a. initial filing
- [ ] b. material change

4. Name and Address of Reporting Entity:

[ ] Prime [x] SubAwardee

* Name: Philadelphia Gas Works
* Street 1: 800 W Montgomery Ave Street 2:
* City: Philadelphia State: PA Zip: 19122

Congressional District, if known:

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

6. * Federal Department/Agency:

US Department of Energy - Office of Clean Energy Demonstrations

7. * Federal Program Name/Description:

FOA-0002779: Regional Clean Hydrogen Hubs

CFDA Number, *if applicable:* 81.255

8. Federal Action Number, *if known:*

9. Award Amount, *if known:*

$

10. a. Name and Address of Lobbying Registrant:

Prefix: * First Name: N/A Middle Name:
* Last Name: N/A Suffix:
* Street 1: Street 2:
* City: State: Zip:

b. Individual Performing Services (including address if different from No. 10a)

Prefix: * First Name: N/A Middle Name:
* Last Name: N/A Suffix:
* Street 1: Street 2:
* City: State: Zip:

11. Information requested through this form is authorized by title 31 U.S.C. section 1352. This disclosure of lobbying activities is a material representation of fact upon which reliance was placed by the tier above when the transaction was made or entered into. This disclosure is required pursuant to 31 U.S.C. 1352. This information will be reported to the Congress semi-annually and will be available for public inspection. Any person who fails to file the required disclosure shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

*** Signature:** Completed on submission to Grants.gov

***Name:** Prefix: * First Name: Elliott Middle Name:
* Last Name: Gold Suffix:

Title: VP, Corporate Planning **Telephone No.:** [redacted] **Date:** Completed on submission to Grants.gov

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DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C.1352

OMB Number: 4040-0013
Expiration Date: 02/28/2025

Review Public Burden Disclosure Statement

1. * Type of Federal Action:
- [ ] a. contract
- [x] b. grant
- [ ] c. cooperative agreement
- [ ] d. loan
- [ ] e. loan guarantee
- [ ] f. loan insurance

2. * Status of Federal Action:
- [ ] a. bid/offer/application
- [x] b. initial award
- [ ] c. post-award

3. * Report Type:
- [x] a. initial filing
- [ ] b. material change

4. Name and Address of Reporting Entity:

[ ] Prime [x] SubAwardee Tier if known:

* Name: PSEG Renewable Ventures LLC
* Street 1: 80 Park Plaza Street 2:
* City: Newark State: NJ: New Jersey Zip: 07102
Congressional District, if known:

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

* Name: Mid-Atlantic Clean Hydrogen Hub Inc
* Street 1: 104 Grand Oaks Street 2:
* City: Dover State: DE: Delaware Zip: 19901
Congressional District, if known:

6. * Federal Department/Agency: Department of Energy

7. * Federal Program Name/Description: Regional Clean Hydrogen Hubs program

CFDA Number, if applicable:

8. Federal Action Number, *if known:*

9. Award Amount, *if known:* $

10. a. Name and Address of Lobbying Registrant:

Prefix: * First Name: N/A Middle Name:
* Last Name: N/A Suffix:
* Street 1: Street 2:
* City: State: Zip:

b. Individual Performing Services (including address if different from No. 10a)

Prefix: * First Name: N/A Middle Name:
* Last Name: N/A Suffix:
* Street 1: Street 2:
* City: State: Zip:

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* **Signature:** Lathrop Craig
1375D4D2E2204E0

***Name:** Prefix: * First Name: Lathrop Middle Name:
* Last Name: Craig Suffix:

Title: **Telephone No.:** **Date:** 3/29/2023

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DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C.1352

OMB Number: 4040-0013
Expiration Date: 02/28/2025

1. * Type of Federal Action:
- [ ] a. contract
- [x] b. grant
- [ ] c. cooperative agreement
- [ ] d. loan
- [ ] e. loan guarantee
- [ ] f. loan insurance

2. * Status of Federal Action:
- [ ] a. bid/offer/application
- [x] b. initial award
- [ ] c. post-award

3. * Report Type:
- [x] a. initial filing
- [ ] b. material change

4. Name and Address of Reporting Entity:

[x] Prime [✓] SubAwardee

* Name: Southeastern Pennsylvania Transportation Authority (SEPTA)
* Street 1: 1234 Market Streeet Street 2:
* City: Philadelphia State: PA Zip: 19107

Congressional District, if known:

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

6. * Federal Department/Agency:
US Department of Energy - Office of Clean Energy Demonstrations

7. * Federal Program Name/Description:
FOA-0002779: Regional Clean Hydrogen Hubs

CFDA Number, *if applicable:* 81.255

8. Federal Action Number, *if known:*

9. Award Amount, *if known:*
$

10. a. Name and Address of Lobbying Registrant:

Prefix: * First Name: N/A Middle Name:
* Last Name: N/A Suffix:
* Street 1: Street 2:
* City: State: Zip:

b. Individual Performing Services (including address if different from No. 10a)

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*** Signature:** Completed on submission to Grants.gov

***Name:** Prefix: * First Name: David Middle Name:
* Last Name: Montvydas Suffix:

Title: SEPTA Chief Engineer - Maintenance of Way **Telephone No.:** **Date:** Completed on submission to Grants.gov

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- [x] b. initial award
- [ ] c. post-award

3. * Report Type:
- [x] a. initial filing
- [ ] b. material change

4. Name and Address of Reporting Entity:

[x] Prime [✓] SubAwardee

* Name: sHYp BV, A Public Benefit Corporation
* Street 1: 1110 Cliffhurst Rd   Street 2:
* City: Baltimore   State: MD   Zip: 21210

Congressional District, if known:

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

6. * Federal Department/Agency: US Department of Energy - Office of Clean Energy Demonstrations

7. * Federal Program Name/Description: FOA-0002779: Regional Clean Hydrogen Hubs

CFDA Number, *if applicable:* 81.255

8. Federal Action Number, *if known:*

9. Award Amount, *if known:* $

10. a. Name and Address of Lobbying Registrant:

Prefix: * First Name: N/A   Middle Name:
* Last Name: N/A   Suffix:
* Street 1:   Street 2:
* City: State: Zip:

b. Individual Performing Services (including address if different from No. 10a)

Prefix: * First Name: N/A   Middle Name:
* Last Name: N/A   Suffix:
* Street 1:   Street 2:
* City: State: Zip:

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*** Signature:** Completed on submission to Grants.gov

***Name:** Prefix: * First Name: Lauren   Middle Name:
* Last Name: Greenlee   Suffix:

Title: Chief Technology Officer   **Telephone No.:** [redacted]   **Date:** Completed on submission to Grants.gov

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- [x] a. bid/offer/application
- [ ] b. initial award
- [ ] c. post-award

3. * Report Type:
- [x] a. initial filing
- [ ] b. material change

4. Name and Address of Reporting Entity:

[ ] Prime [x] SubAwardee Tier if known: 1

* Name: University of Delaware
* Street 1: 210 Hullihen Hall Street 2:
* City: Newark State: DE: Delaware Zip: 19716-0099
Congressional District, if known: DE-001

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

* Name: Mid-Atlantic Clean Hydrogen Hub
* Street 1: 104 Grand Oaks Drive Street 2:
* City: Dover State: DE: Delaware Zip: 19901
Congressional District, if known: DE-001

6. * Federal Department/Agency: US Department of Energy/OCED

7. * Federal Program Name/Description: FOA-0002779: Regional Clean Hydrogen Hubs

CFDA Number, *if applicable:* 81-255

8. Federal Action Number, *if known:*

9. Award Amount, *if known:* $

10. a. Name and Address of Lobbying Registrant:

Prefix: * First Name: N/a Middle Name:
* Last Name: N/a Suffix:
* Street 1: Street 2:
* City: State: Zip:

b. Individual Performing Services (including address if different from No. 10a)

Prefix: * First Name: N/a Middle Name:
* Last Name: N/a Suffix:
* Street 1: N/a Street 2:
* City: N/a State: DE: Delaware Zip:

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*** Signature:** [signature]

***Name:** Prefix: * First Name: Elizabeth Middle Name:
* Last Name: Townsend Suffix:

Title: Sr. Contract & Grants Analyst **Telephone No.:** [redacted] **Date:** 03/28/2023

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- [ ] c. post-award

3. * Report Type:

- [ ] a. initial filing
- [ ] b. material change

4. Name and Address of Reporting Entity:

[ ] Prime [x] SubAwardee Tier if known:

* Name: Cheyney University of Pennsylvania
* Street 1: 1837 University Circle
Street 2:
* City: Cheyney
State: PA: Pennsylvania
Zip: 19319

Congressional District, if known:

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

* Name: University of Delaware
* Street 1: 210 Hullihen Hall
Street 2:
* City: Newark
State: DE: Delaware
Zip: 19716-0099

Congressional District, if known: DE-001

6. * Federal Department/Agency:

US Department of Energy/OCED

7. * Federal Program Name/Description:

FOA-0002779: Regional Clean Hydrogen Hubs

CFDA Number, *if applicable:* 81-255

8. Federal Action Number, *if known:*

9. Award Amount, *if known:*

$

10. a. Name and Address of Lobbying Registrant:

Prefix:
* First Name: N/A
Middle Name:
* Last Name: N/A
Suffix:
* Street 1:
Street 2:
* City:
State:
Zip:

b. Individual Performing Services (including address if different from No. 10a)

Prefix:
* First Name: N/A
Middle Name:
* Last Name: N/A
Suffix:
* Street 1:
Street 2:
* City:
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Zip:

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*** Signature:**

***Name:** Prefix: Ms. * First Name: Cynthia Middle Name:
* Last Name: Moultrie Suffix:

Title: Chief Financial Officer **Telephone No.:** **Date:** [illegible]

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DISCLOSURE OF LOBBYING ACTIVITIES

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- [x] a. bid/offer/application
- [x] b. initial award
- [ ] c. post-award

3. * Report Type:

- [x] a. initial filing
- [ ] b. material change

4. Name and Address of Reporting Entity:

[x] Prime [x] SubAwardee

* Name: Versogen
* Street 1: 1090 Elkton Road Street 2: S115
* City: Newark State: DE Zip: 19711

Congressional District, if known:

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

6. * Federal Department/Agency: US Department of Energy

7. * Federal Program Name/Description:

CFDA Number, *if applicable:*

8. Federal Action Number, *if known:*

9. Award Amount, *if known:* $

10. a. Name and Address of Lobbying Registrant:

Prefix: * First Name: N/A Middle Name:
* Last Name: Suffix:
* Street 1: Street 2:
* City: State: Zip:

b. Individual Performing Services (including address if different from No. 10a)

Prefix: * First Name: N/A Middle Name:
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*** Signature:** Completed on submission to Grants.gov [signature: L Balas]

***Name:** Prefix: * First Name: Balasubramanian Middle Name:
* Last Name: Lakshmanan Suffix:

Title: Chief Technology Officer **Telephone No.:** **Date:** Completed on submission to Grants.gov Mar 23 2023

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2779-1593: H2Hub Overview

Project Title: Mid-Atlantic Clean Hydrogen Hub (MACH2)

Prime Applicant: Mid-Atlantic Clean Hydrogen Hub, Inc.

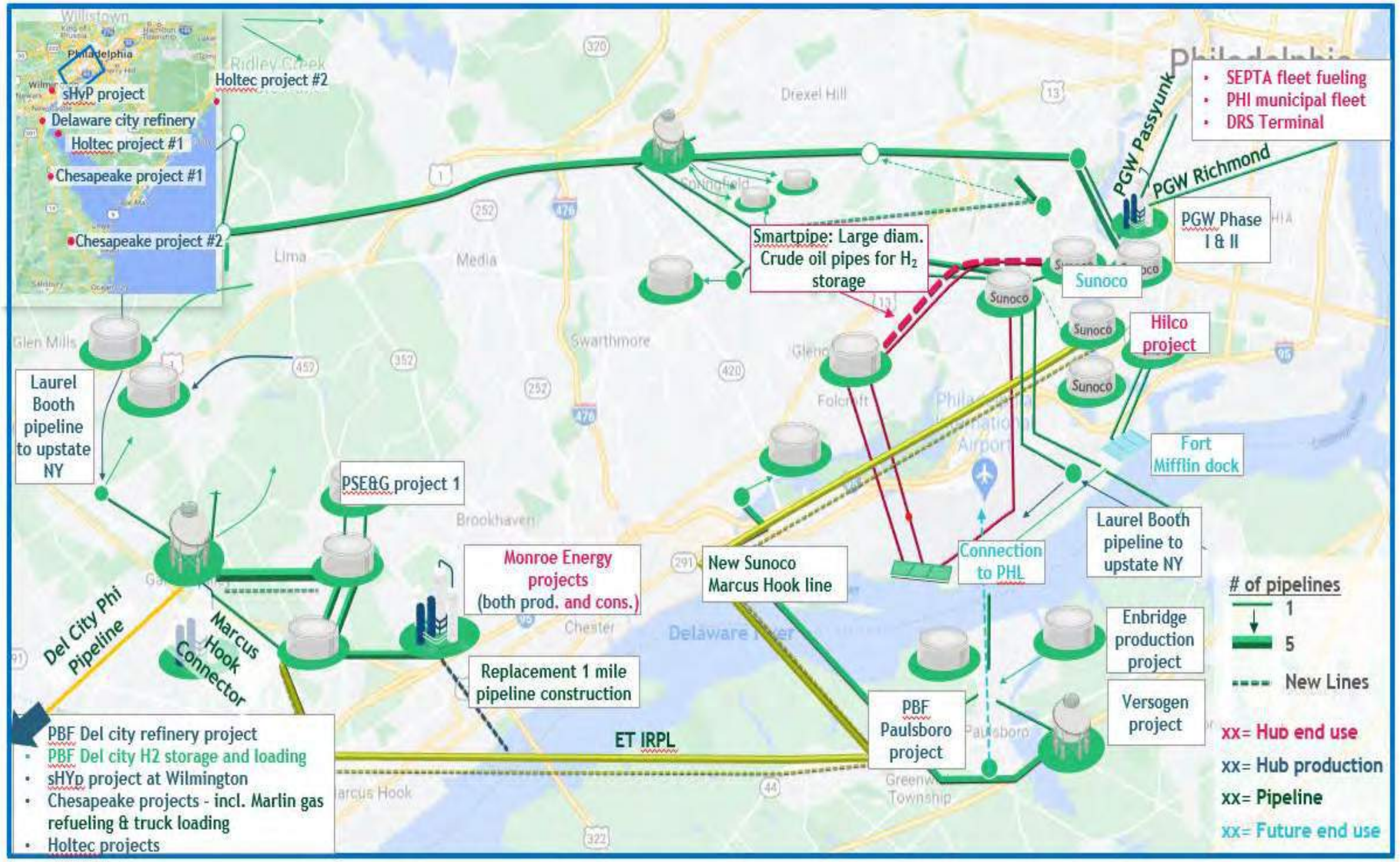
Major goals/objectives:

- Generate clean, zero-emission green and pink H2
- Reuse and revitalize existing infrastructure
- Create and retain 13,000-20,000 jobs
- Provide economic opportunity and health improvements across the region

Budget:

- Requested DOE funds: $839,580,350
- Proposed applicant cost share: $2,190,818,933
- Cost share % (cost share / Total) 72.29%
- Total (DOE + cost share) $3,030,399,283

Geographical Region: PA – NJ – DE



2779-1593: H2Hub Organizational Chart

BOARD OF DIRECTORS (BOD)

Up to 15 individuals that represent all 3 states, the Board of Directors holds all fiduciary responsibility for the organization, and authorizes/manages the movement of money, establishing and approval of by-laws and codes of conduct.

ADVISORY COMMITTEES (AC)

Subject matter experts to advise both the BOD and the CEO/Executive Team on hub planning and execution. Members of the AC can also be members of the BOD as well as members of any ad hoc sub-committees formed for the execution of the hydrogen hub. Initially two AC's as a minimum: Industry/Technical and Community/Workforce Development, more to be developed if required.

Industry AC

Representatives from industry such as Air Liquide, Bayotech, Bloom Energy, Buckeye, CMS, Enbridge, Holtec, Monroe Energy, PBF Energy, PGW, PSEG, Versogen, Schuyler Energy, South River Maritime, MDavis, Engineering, Compliance & Regulatory Expertise

Community AC

Environmental Justice Expertise, DESCA, Chambers of Commerce, UD, UPenn, Rowan, DSU, DTCC, DE Work-force Development Board, Union reps, Philadelphia Works, DEI&A reps, FAME, Inc

CHIEF EXECUTIVE OFFICER

HR Director

Executive Administrator

The CEO will report to the BOD and be accountable for executing the H2Hub plan as specified in the proposal submitted to the DOE. The CEO will be responsible for forming and hiring the executive team and, staff, and consultants needed to execute on the plan. This team will also be responsible for forming any and all ad hoc sub-committees required for the execution of the hydrogen hub plan.

COO, Technology Director & Staff

Responsibilities include (but not limited to): ensuring that hub operations meet or exceed expectations; business management, growth planning, key contract management, engineering, design and procurement, technology & performance projections, execution schedules, safety, security & regulatory requirements, technical data & analysis

CFO & Staff

Responsibilities include (but not limited to): financial management & planning, federal funding management & compliance, non-federal funding compliance

Community Benefits Lead & Staff

Responsibilities include (but not limited to): environmental justice planning & execution, community partnerships & outreach, community benefits planning and execution; workforce development planning and execution; partnerships with schools, colleges and unions to develop workforce training & retraining programs, internships, apprenticeships

General Counsel

In the short term, General Counsel will be an outsourced role. As the hub develops and grows, this role may be brought in-house

Consultant(s) and ad hoc sub-committees as required

2779-1593: H2Hub Project Schedule

Phase 1

Detailed Project Planning

- March 2024-June 2025
- (15 months / 1.25 years)

- Initial planning and analysis to ensure concept is technologically and financially viable
- Detailed engineering work
- Proving of technologies, including **SmartPipe** for retrofitting existing pipelines, **sHYp** electrolyzer technology utilizing saltwater, and **Versogen** electrolyzer technology utilizing AEM
- **PSEG** site selection, **Holtec** permitting, **Enbridge** permitting, **Messer** site selection, **Chesapeake** permitting, **PGW** permitting, **PBF** engineering development
- **SEPTA's** first H2 bus, **City of Philadelphia's** H2 fueled trash trucks

Phase 2

Project Development, Permitting, and Financing

- June 2025-March 2028
- (33 months / 2.75 years)

- Finalize Engineering designs, business development, site access, labor agreements, permitting, offtake agreements, community engagement activities
- **sHYp** electrolyzer done second pilot phase, **Versogen** electrolyzer done second pilot phase
- **PBF** plant startup, **PSEG** procurement of all equipment, **Holtec** plant construction for first project, **Enbridge** plant construction, **Messer** plant construction, **Chesapeake** plant startup, **PGW** completed project, **Holtec** SMR project start
- **SEPTA** and **City** add H2 vehicles, **Monroe** and **Dupont** use H2 to feed boilers

Phase 3

Installation, Integration, and Construction

- March 2028-March 2031
- (36 months / 3 years)

- Installation, integration, and construction activities
- **sHYp** tech done final pilot phase and begins plant construction, **Versogen** tech done final pilot phase and begins plant construction
- **Holtec** finalizes permits and completes risk assessment for second project, Oyster Creek
- **SEPTA** and **City** add H2 vehicles, **Hilco** uses H2 to power microgrid

Phase 4

Ramp Up and Sustained Operations

- March 2031-March 2034
- (36 months / 3 years)

- Complete all unfinished projects
- Ramp up to full hub operations
- Fully operational hub will improve environmental outcomes in the region, train and develop next generation of energy workers, increase the wellbeing of old energy infrastructure fence line communities, provide good paying jobs to disadvantaged communities.
- Contribute to the development and sustainability of a nationwide clean hydrogen network.

2779-1593: H2Hub Business Model

Business model overview

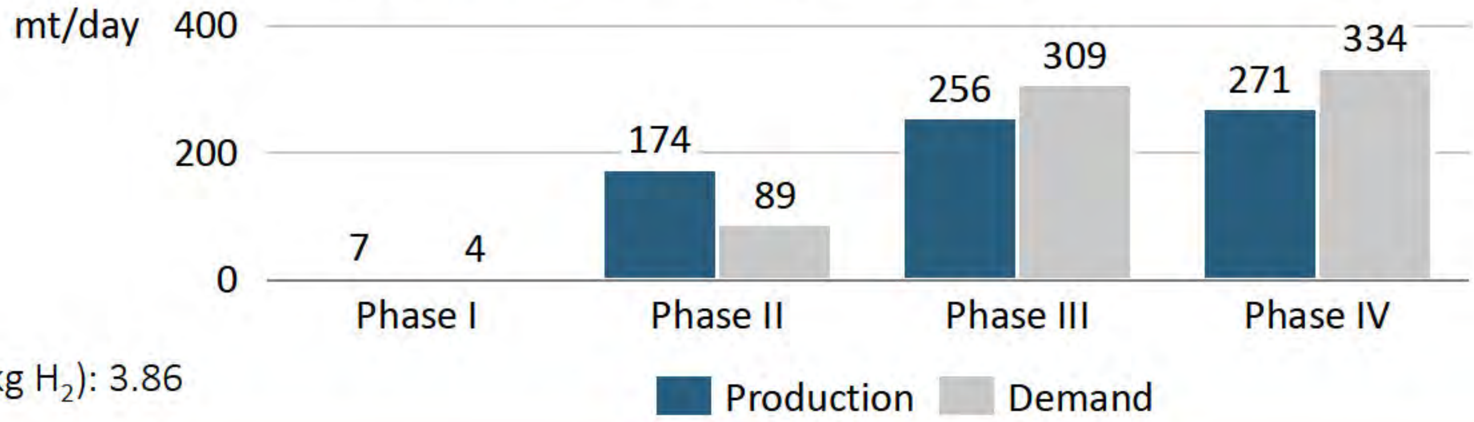
- MACH2 optimized selection of projects across three key criteria:
  - Average at gate hydrogen costs produced over lifetime of project
  - Magnitude and balance of hydrogen produced and used in the hub
  - Geographic proximity to key infrastructure

	Federal Share	Cost Share	Total Project	Cost Share %
Phase 1	$19.7M	$99.2M	$118.9M	83%
Phase 2	$125.2M	$426.7M	$552.1M	77%
Phase 3	$559.7M	$1.36B	$1.93B	71%
Phase 4	$134.8M	$296.4M	$431.2M	68%
Total	$839.5M	$2.19B	$3.03B	72%

Key hub metrics:

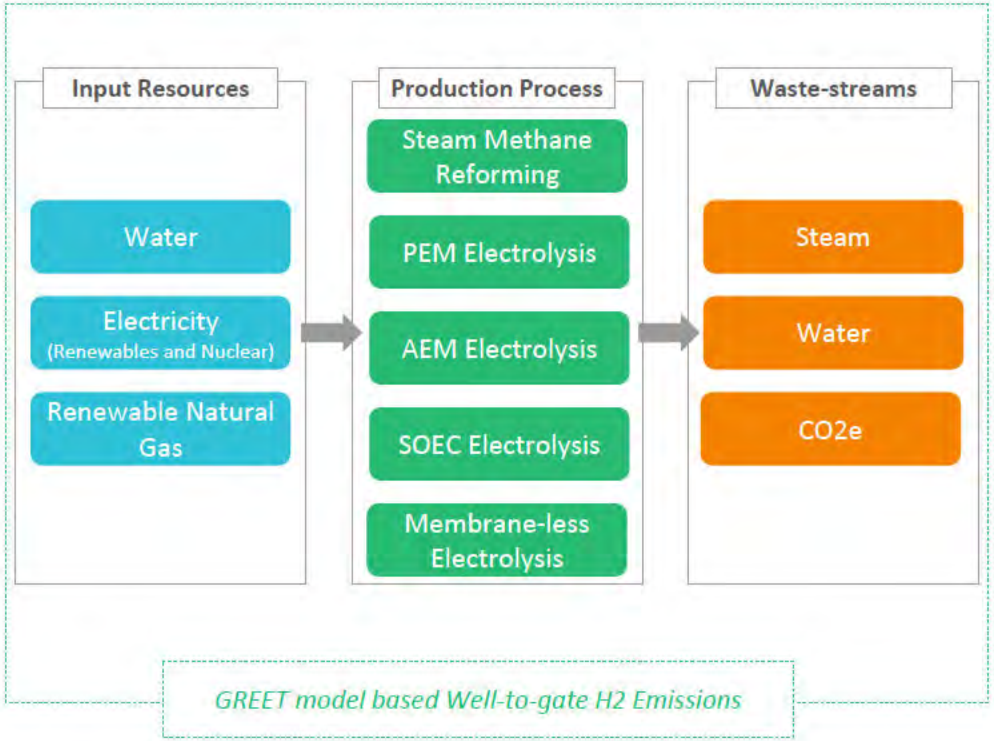
- 10-year IRR: 11.5%
- 30-year IRR: 13.4%
- Total Capex cost: $2.7B
- Total DOE Funding request: $839M
- Partner's DOE funding: $701M
- Total production (tpd): 271
- Total demand (tpd): 334
- Overall 2030 hub production LCOH ($/kg H_2): 3.86

Hydrogen production and demand in tpd



2779-1593: H2Hub LCA Impacts

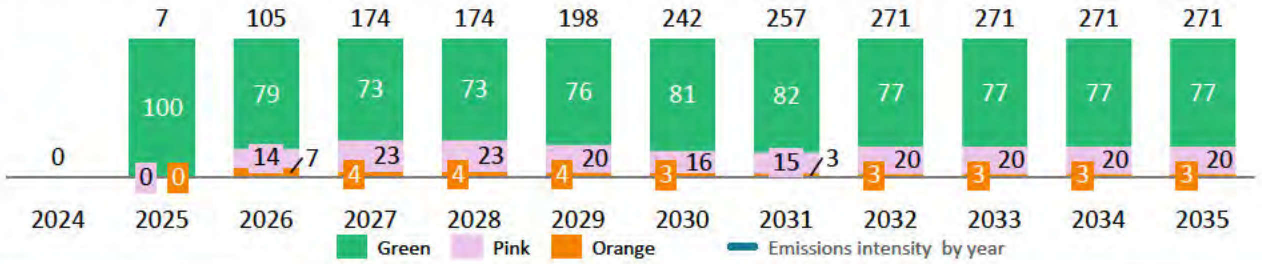
Life-cycle Assessment Approach[1]



Life-cycle Assessment Impacts

MACH2's carbon intensity LCA analysis shows average of -0.17 kg CO2e/kg H2 2024-2035

Overview of hydrogen production by % type over life of the hub (total in mt/day)



Greet Model Default LCAs (kg CO_2e / kg H_2)

Orange (RNG w/ CCS): -6.5 | Pink (Nuclear SOEC): 0.2 | Green (Hydro, Solar or Wind powered PEM): 0

Electricity use in peak year (2032):

5,500 GWh / year

4,500 GWh / year (80%) renewable energy for green H2 production – ~1.7GW installed capacity[2]

Water needs in peak year (2032):

590M gal

Water consumption equivalent to that of 1% of residents in the city of Philadelphia in a year[3]

1. Renewable Natural Gas (RNG) only needed for Orange H2 production which has other waste streams represented as CO2e equivalent as per the GREET model. CO2e emissions (CO2e per kg H2) are Green H2: 0, Pink H2: 0.2, Orange H2 without CCS: 0.2, and Orange H2 with CCS: (6.5) 2. Assumes blanket 30% capacity factor for renewable energy generation (based on on-shore wind CF of 30%, solar of 20%, and expected technological improvements over time). Capacity will be secured by project partners through a mix of PPAs and on-site generation development 3. City of Philadelphia resident uses 100 gallons / day or 37,000 gallons/ year; 580M gallons is equivalent to 16,000 residents (~1% of population)

2779-1593: H2Hub Community Benefits Plan

COMM. & LAB. ENGAGE.	**LAY FOUNDATIONS AND CO-DESIGN COMMUNITY AND LABOR ENGAGEMENT** *Building trusting relationships between Community Based Organizations and industry partners to strengthen the network of*
	GENERATE SHARED PATHWAYS *Co-designing strategies and specific objectives for impactful community projects*
	FACILITATE OUTREACH & PROGRAMMING THROUGH WORKING GROUPS *Enabling effective two-way communication between affected communities and MACH2 working groups*
WORKFORCE	**DEVELOP BROADLY ACCESSIBLE H2 TRAINING PROGRAMS & CURRICULA** *High school & vo-tech CTE, pre/apprenticeships, certificates, stackable credentials, BS, MS, PhD, on-the-job training*
	ATTRACT DIVERSE POPULATIONS TO H2 TRAINING & JOBS *Recruit underserved popoulations (URMs/women/veterans/low-income) to H2 economy; Hire locally*
	SUPPORT LABOR UNIONS *Negotiate PLAs; Construction phase uses only union labor; Diversify skilled trades*
DEIA	**COMMIT TO DEIA THROUGH SHARED UNDERSTANDING** *Conducting a systematic assessment of current state of DEIA and commiting to engaging in governance and operational*
	PRIORITIZE EQUITY CENTERED STRATEGIC PARTNERSHIP *Engaging equity-centered strategic partners to support and implement DEIA vision*
	FOSTER SHARED DECISION MAKING *Meaningfully including people and groups who have historically borne the greatest burdens in MACH2 decision making*
J40	**DECREASE ENVIRONMENTAL EXPOSURES & BURDENS AND DECREASED ENERGY BURDENS** *Improved air & water quality; lower risk indices; lower household energy costs*
	INCREASE ACCESS TO LOW-COST CAPITAL, ENERGY ENTERPRISE CREATION & CONTRACTING *More contracts and higher $ amounts for MBE/WBE/DBE, veteran/LGBTQ businesses*
	INCREASE ENERGY RESILIENCY, ENERGY DEMOCRACY, AND CLEAN ENERGY JOBS *Micro-Grids/Home Retrofits/Local providers and hiring/Accessible H2 training and pathways to jobs & apprenticeships*

MACH2's goals for the Community Benefits Plan are:

1. To create a culture of collaboration and structures of shared-decision-making with stakeholder communities;
2. To enable the new economy, and broaden access to new energy jobs in order to do so;
3. To support worker rights through prioritizing working conditions, labor agreements and policies;
4. To meaningfully commit to Diversity, Equity, Inclusion and Accessibility (DEIA);
5. To design projects that ensure those who historically borne the greatest burden will receive >40% of the benefits from the project.

EERE T 540.132 02 Budget Justification (5 BPs)

Instructions and Summary

OMB Control Number: 1910-5162
Expiration Date: 04/30/2025

Award Number:

Award Recipient: Chesapeake Utilities

Date of Submission: 4/5/2023

Form submitted by: Mid-Atlantic Clean Hydrogen Hub, Inc.
(May be award recipient or sub-recipient)

Please read the instructions on each worksheet tab before starting. If you have any questions, please ask your EERE contact!
Do not modify this template or any cells or formulas!

1. If using this form for award application, negotiation, or budget revision, fill out the blank white cells in workbook tabs a. through j. with total project costs.
2. Blue colored cells contain instructions, headers, or summary calculations and should not be modified. Only blank white cells should be populated.
3. Enter detailed support for the project costs identified for each Category line item within each worksheet tab to autopopulate the summary tab.
4. The total budget presented on tabs a. through i. must include both Federal (DOE) and Non-Federal (cost share) portions.
5. All costs incurred by the preparer's sub-recipients, contractors, and Federal Research and Development Centers (FFRDCs), should be entered only in section f. Contractual. All other sections are for the costs of the preparer only.
6. Ensure all entered costs are allowable, allocable, and reasonable in accordance with the administrative requirements prescribed in 2 CFR 200, and the applicable cost principles for each entity type: FAR Part 31 for For-Profit entities; and 2 CFR Part 200 Subpart E - Cost Principles for all other non-federal entities.
7. Add rows as needed throughout tabs a. through j. If rows are added, formulas/calculations may need to be adjusted by the preparer. Do not add rows to the Instructions and Summary tab. If your project contains more than five budget periods, consult your EERE contact before adding additional budget period rows or columns.
8. ALL budget period cost categories are rounded to the nearest dollar.

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

d. Equipment

INSTRUCTIONS - PLEASE READ!!!

1. Equipment is generally defined as an item with an acquisition cost greater than $5,000 and a useful life expectancy of more than one year. Please refer to the applicable Federal regulations in 2 CFR 200 for specific equipment definitions and treatment.

2. List all equipment below, providing a basis of cost (e.g. contractor quotes, catalog prices, prior invoices, etc.). Briefly justify items as they apply to the Statement of Project Objectives. If it is existing equipment, provide logical support for the estimated value shown.

3. During award negotiations, provide a contractor quote for all equipment items over $50,000 in price. If the contractor quote is not an exact price match, provide an explanation in the additional explanation section below. If a contractor quote is not practical, such as for a piece of equipment that is purpose-built, first of its kind, or otherwise not available off the shelf, provide a detailed engineering estimate for how the cost estimate was derived.

4. Each budget period is rounded to the nearest dollar.

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

f. Contractual

INSTRUCTIONS - PLEASE READ!!!

1. The entity completing this form must provide all costs related to sub-recipients, contractors, and FFRDC partners in the applicable boxes below.

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5. Each budget period is rounded to the nearest dollar.

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Instructions and Summary

OMB Control Number: 1910-5162
Expiration Date: 04/30/2025

Award Number:
Award Recipient: Chesapeake Utilities

Date of Submission: 4/5/2023
Form submitted by: Mid-Atlantic Clean Hydrogen Hub, INC
(May be award recipient or sub-recipient)

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BURDEN DISCLOSURE STATEMENT

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

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SOPO	Equipment Item	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

f. Contractual

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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Instructions and Summary

OMB Control Number: 1910-5162
Expiration Date: 04/30/2025

Award Number:
Award Recipient: Chesapeake Utilities

Date of Submission: 4/5/2023
Form submitted by: Mid-Atlantic Clean Hydrogen Hub, INC
(May be award recipient or sub-recipient)

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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

EERE T 540.132 02 Budget Justification (5 BPs)

Instructions and Summary

OMB Control Number: 1910-5162
Expiration Date: 04/30/2025

Award Number:
Award Recipient: Chesapeake Utilities

Date of Submission: 4/5/2023
Form submitted by: Mid-Atlantic Clean Hydrogen Hub, INC
(May be award recipient or sub-recipient)

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BURDEN DISCLOSURE STATEMENT

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

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d. Equipment

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SOPO	Equipment Item	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need
Budget Period 1						

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

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f. Contractual

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[redacted]

the fleet consists trailers that are 46 feet in length and have four steel tubes capable of holding hydrogen at 3000 PSIG
Marlin is looking to increase the hydrogen trailer fleet and supplement the existing trailers with additional units built by Quantum
the units that are being specified are VP 5000-H which have a water capacity of 50,292 liters and operate at 5000 PSIG and are capable of carrying 2634 pounds of hydrogen
Marlin has worked already worked closely with quantum and has purchased CNG trailers with a great deal of success and reliable operation

Specifications for on-site delivery (storage tanks, power supply, footprint, etc.):
As the trailers to the accepted dimensions to operate on the US highways the turning circle four days Unix would be similar to those required
for a 45-foot trailer. Will be delivered to the sides at 5000 PSIG , however, the hydrogen tanker pressure at would be 200 PSIG.
therefore it will be necessary to have a hydrogen compressor on the site to be able to increase the pressure to the storage pressure within the tank

g. Construction

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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

EERE T 540.132 02 Budget Justification (5 BPs)

Instructions and Summary

OMB Control Number: 1910-5162
Expiration Date: 04/30/2025

Award Number:
Award Recipient: Enbridge Energy

Date of Submission: 4/5/2023
Form submitted by: Mid-Atlantic Clean Hydrogen Hub, INC
(May be award recipient or sub-recipient)

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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

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d. Equipment

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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

g. Construction

[redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Instructions and Summary

OMB Control Number: 1910-5162
Expiration Date: 04/30/2025

Award Number:
Award Recipient: Hilco Redevelopment Partners

Date of Submission: 4/5/2023
Form submitted by: Mid-Atlantic Clean Hydrogen Hub, INC
(May be award recipient or sub-recipient)

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BURDEN DISCLOSURE STATEMENT
Public reporting burden for this collection of information is estimated to average 24 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Office of Information Resources Management Policy, Plans, and Oversight, AD-241-2 - GTN, Paperwork Reduction Project (1910-5162), U.S. Department of Energy 1000 Independence Avenue, S.W., Washington, DC 20585; and to the Office of Management and Budget, Paperwork Reduction Project (1910-5162), Washington, DC 20503.

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

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SOPO	Equipment Item	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need
Budget Period 1						

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

h. Other Direct Costs

INSTRUCTIONS - PLEASE READ!!!

1. Other direct costs are direct cost items required for the project which do not fit clearly into other categories. These direct costs must not be included in the indirect costs (for which the indirect rate is being applied for this project). Examples are: tuition, printing costs, etc. which can be directly charged to the project and are not duplicated in indirect costs (overhead costs).

2. Basis of cost are items such as vendor quotes, prior purchases of similar or like items, published price list, etc.

3. Each budget period is rounded to the nearest dollar.

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

i. Indirect Costs

INSTRUCTIONS - PLEASE READ!!!

1. Fill out the table below to indicate how your indirect costs are calculated. Use the box below to provide additional explanation regarding your indirect rate calculation.

2. The rates and how they are applied should not be averaged to get one indirect cost percentage. Complex calculations or rates that do not do not correspond to the below categories should be described/provided in the Additional Explanation section below. If questions exist, consult with your DOE contact before filling out this section.

3. The indirect rate should be applied to both the Federal Share and Recipient Cost Share.

4. NOTE: A Recipient who elects to employ the 10% de minimis Indirect Cost rate **cannot claim resulting costs as a Cost Share contribution, nor can the Recipient claim "unrecovered indirect costs" as a Cost Share contribution.** Neither of these costs can be reflected as actual indirect cost rates realized by the organization, and therefore are not verifiable in the Recipient records as required by Federal Regulation (§200.306(b)(1)).

5. Each budget period is rounded to the nearest dollar.

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

EERE T 540.132 02 Budget Justification (5 BPs)

Instructions and Summary

OMB Control Number: 1910-5162
Expiration Date: 04/30/2025

Award Number:
Award Recipient: Holtec

Date of Submission: 4/5/2023
Form submitted by: Mid-Atlantic Clean Hydrogen Hub, INC
(May be award recipient or sub-recipient)

Please read the instructions on each worksheet tab before starting. If you have any questions, please ask your EERE contact!
Do not modify this template or any cells or formulas!

1. If using this form for award application, negotiation, or budget revision, fill out the blank white cells in workbook tabs a. through j. with total project costs.
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4. The total budget presented on tabs a. through i. must include both Federal (DOE) and Non-Federal (cost share) portions.
5. All costs incurred by the preparer's sub-recipients, contractors, and Federal Research and Development Centers (FFRDCs), should be entered only in section f. Contractual. All other sections are for the costs of the preparer only.
6. Ensure all entered costs are allowable, allocable, and reasonable in accordance with the administrative requirements prescribed in 2 CFR 200, and the applicable cost principles for each entity type: FAR Part 31 for For-Profit entities; and 2 CFR Part 200 Subpart E - Cost Principles for all other non-federal entities.
7. Add rows as needed throughout tabs a. through j. If rows are added, formulas/calculations may need to be adjusted by the preparer. Do not add rows to the Instructions and Summary tab. If your project contains more than five budget periods, consult your EERE contact before adding additional budget period rows or columns.
8. ALL budget period cost categories are rounded to the nearest dollar.

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

d. Equipment

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

f. Contractual

INSTRUCTIONS - PLEASE READ!!!

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2. Sub-recipients (partners, sub-awardees): Subrecipients shall submit a Budget Justification describing all project costs and calculations when their total proposed budget exceeds either (1) $250,000 or (2) 25% of total award costs. These sub-recipient forms may be completed by either the sub-recipients themselves or by the preparer of this form. The budget totals on the sub-recipient's forms must match the sub-recipient entries below. A subrecipient is a legal entity to which a subaward is made, who has performance measured against whether the objectives of the Federal program are met, is responsible for programmatic decision making, must adhere to applicable Federal program compliance requirements, and uses the Federal funds to carry out a program of the organization. All characteristics may not be present and judgment must be used to determine subrecipient vs. vendor status.

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4. Federal Funded Research and Development Centers (FFRDCs): FFRDCs must submit a signed Field Work Proposal during award application. The award recipient may allow the FFRDC to provide this information directly to DOE, however project costs must also be provided below.

5. Each budget period is rounded to the nearest dollar.

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

g. Construction

PLEASE READ!!!
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2. List all proposed construction below, providing a basis of cost such as engineering estimates, prior construction, etc., and briefly justify its need as it applies to the Statement of Project Objectives.
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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Instructions and Summary

OMB Control Number: 1910-5162
Expiration Date: 04/30/2025

Award Number:
Award Recipient: Holtec

Date of Submission: 4/5/2023
Form submitted by: Mid-Atlantic Clean Hydrogen Hub, INC
(May be award recipient or sub-recipient)

Please read the instructions on each worksheet tab before starting. If you have any questions, please ask your EERE contact!
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BURDEN DISCLOSURE STATEMENT

Public reporting burden for this collection of information is estimated to average 24 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Office of Information Resources Management Policy, Plans, and Oversight, AD-241-2 - GTN, Paperwork Reduction Project (1910-5162), U.S. Department of Energy 1000 Independence Avenue, S.W., Washington, DC 20585; and to the Office of Management and Budget, Paperwork Reduction Project (1910-5162), Washington, DC 20503.

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

d. Equipment

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

f. Contractual

INSTRUCTIONS - PLEASE READ!!!

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4. Federal Funded Research and Development Centers (FFRDCs): FFRDCs must submit a signed Field Work Proposal during award application. The award recipient may allow the FFRDC to provide this information directly to DOE, however project costs must also be provided below.

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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

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2. List all proposed construction below, providing a basis of cost such as engineering estimates, prior construction, etc., and briefly justify its need as it applies to the Statement of Project Objectives.
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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Instructions and Summary

OMB Control Number: 1910-5162
Expiration Date: 04/30/2025

Award Number:
Award Recipient: Messer LLC

Date of Submission: 5-Apr-2023
Form submitted by: Mid-Atlantic Hydrogen Hub, INC.
(May be award recipient or sub-recipient)

Please read the instructions on each worksheet tab before starting. If you have any questions, please ask your EERE contact!
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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

d. Equipment

INSTRUCTIONS - PLEASE READ!!!

1. Equipment is generally defined as an item with an acquisition cost greater than $5,000 and a useful life expectancy of more than one year. Please refer to the applicable Federal regulations in 2 CFR 200 for specific equipment definitions and treatment.

2. List all equipment below, providing a basis of cost (e.g. contractor quotes, catalog prices, prior invoices, etc.). Briefly justify items as they apply to the Statement of Project Objectives. If it is existing equipment, provide logical support for the estimated value shown.

3. During award negotiations, provide a contractor quote for all equipment items over $50,000 in price. If the contractor quote is not an exact price match, provide an explanation in the additional explanation section below. If a contractor quote is not practical, such as for a piece of equipment that is purpose-built, first of its kind, or otherwise not available off the shelf, provide a detailed engineering estimate for how the cost estimate was derived.

4. Each budget period is rounded to the nearest dollar.

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

f. Contractual

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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

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g. Construction

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2. List all proposed construction below, providing a basis of cost such as engineering estimates, prior construction, etc., and briefly justify its need as it applies to the Statement of Project Objectives.

3. Each budget period is rounded to the nearest dollar.

Overall description of construction activities: Example Only!!! - Build wind turbine platform

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Instructions and Summary

OMB Control Number: 1910-5162
Expiration Date: 04/30/2025

Award Number:
Award Recipient: Monroe Energy, Trainer, PA

Date of Submission: 4/5/2023
Form submitted by: Mid-Atlantic Clean Hydrogen Hub, INC
(May be award recipient or sub-recipient)

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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

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d. Equipment

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SOPO	Equipment Item	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need
				Budget Period 1		

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

f. Contractual

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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

g. Construction

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3. Each budget period is rounded to the nearest dollar.

Overall description of construction activities: **Example Only!!! - Build wind turbine platform**

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Instructions and Summary

OMB Control Number: 1910-5162
Expiration Date: 04/30/2025

Award Number:
Award Recipient: Philadelphia Gas Works (PGW)

Date of Submission: 4/5/2023
Form submitted by: Mid-Atlantic Clean Hydrogen Hub, INC

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

f. Contractual

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

g. Construction

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

d. Equipment

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

g. Construction

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

d. Equipment

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

g. Construction

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

[redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

[redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

$53,730,000

Instructions and Summary

Award Number:

Date of Submission: 3/31/2023

Award Recipient: PSEG

Form submitted by: Mid-Atlantic Clean Hydrogen Hub, Inc.

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

d. Equipment

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

f. Contractual

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

h. Other Direct Costs

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

i. Indirect Costs

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Instructions and Summary

Award Number:

Award Recipient: SEPTA

Date of Submission:

Form submitted by: Mid-Atlantic Clean Hydrogen Hub, Inc.

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Cost Share

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Instructions and Summary

Award Number:
Award Recipient: sHYp

Date of Submission: 4/5/2023
Form submitted by: Mid-Atlantic Clean Hydrogen Hub, INC
(May be award recipient or sub-recipient)

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

d. Equipment

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Instructions and Summary

OMB Control Number: 1910-5162
Expiration Date: 04/30/2025

Award Number:
Award Recipient: Versogen

Date of Submission: 4/5/2023
Form submitted by: Mid-Atlantic Clean Hydrogen Hub, INC

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Detailed Budget Justification

a. Personnel

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

c. Travel

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

e. Supplies

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

g. Construction

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

h. Other Direct Costs

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Applicant Name: ______ Award Number: ______

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Instructions for the SF-424A

Public Reporting Burden for this collection of information is estimated to average 3.0 hours per response, including the time for reviewing instructions, searching existing data sources, gathering maintaining the data needed, and completing and reviewing the collection of information. Please do not return your completed form to the Office of Management and Budget; send it to the addre provided by the sponsoring agency.

General Instructions
This form is designed so that application can be made for funds from one or more grant programs. In preparing the budget, adhere to any existing Federal grantor agency guidelines which prescribe how and whether budgeted amounts should be separately shown for different functions or activities within the program. For some programs, grantor agencies may require budgets to be separately shown by function or activity. For other programs, grantor agencies may require a breakdown by function or activity. Sections A, B, C, and D should include budget estimates for the whole project except when applying for assistance which requires Federal authorization in annual or other funding period increments. In the later case, Sections A, B, C, and D should provide the budget for the first budget period (usually a year) and Section E should present the need for Federal assistance in the subsequent budget periods. All applications should contain a breakdown by the object class categories shown in Lines a-k of Section B.

Section A. Budget Summary Lines 1-4 Columns (a) and (b)
For applications pertaining to a **single** Federal grant program (Federal Domestic Assistance Catalog number) and **not requiring** a functional or activity breakdown, enter on Line 1 under Column (a) the catalog program title and the catalog number in Column (b).

For applications pertaining to a **single** program **requiring** budget amounts by multiple functions or activities, enter the name of each activity or function on each line in Column (a), and enter the catalog number in Column (b). For applications pertaining to multiple programs where none of the programs require a breakdown by function or activity, enter the catalog program title on each line in **Column** (a) and the respective catalog number on each line in Column (b).
For applications pertaining to **multiple** programs where one or more programs **require** a breakdown by function or activity, prepare a separate sheet for each program requiring the breakdown. Additional sheets should be used when one form does not provide adequate space for all breakdown of data required. However, when more than one sheet is used, the first page should provide the summary totals by programs.

Lines 1-4, Columns (c) through (g)

For new applications, leave Columns (c) and (d) blank. For each line entry in Columns (a) and (b), enter in Columns (e), (f), and (g) the appropriate amounts of funds needed to support the project for the first funding period (usually a year).

For continuing grant program applications, submit these forms before the er each funding period as required by the grantor agency. Enter in Columns (c) an estimated amounts of funds which will remain unobligated at the end of the grar period only if the Federal grantor agency instructions provide for this. Otherwise these columns blank. Enter in columns (e) and (f) the amounts of funds needed upcoming period. The amount(s) in Column (g) should be the sum of amounts i Columns (e) and (f).

For supplemental grants and changes to existing grants, do not use Columns and (d). Enter in Column (e) the amount of the increase or decrease of Federal and enter in Column (f) the amount of the increase or decrease of non-Federal Column (g) enter the new total budgeted amount (Federal and non-Federal) wh includes the total previous authorized budgeted amounts plus or minus, as appr the amounts shown in Columns (e) and (f). The amount(s) in Column (g) should equal the sum of amounts in Columns (e) and (f).

Line 5—Show the totals for all columns used.

Section B. Budget Categories
In the column headings (a) through (4), enter the titles of the same programs, functions, and activities shown on Lines 1-4, Column (a), Section A. When additional sheets are prepared for Section A, provide similar column headings o sheet. For each program, function or activity, fill in the total requirements for fun Federal and non-Federal) by object class categories.

Lines 6a-i—Show the totals of Lines 6a to 6h in each column.

Line 6j—Show the amount of indirect cost.

Line 6k—Enter the total of amounts on Lines 6i and 6j. For all applications for n grants and continuation grants the total amount in column (5), Line 6k, should b same as the total amount shown in Section A, Column (g), Line 5. For suppleme grants and changes to grants, the total amount of the increase or decrease as s Columns (1)-(4), Line 6k should be the same as the sum of the amounts in Sect Columns (e) and (f) on Line 5.
Line 7—Enter the estimated amount of income, if any, expected to be generate this project. Do not add or subtract this amount from the total project amount. Sl under the program narrative statement the nature and source of income. The es amount of program income may be considered by the federal grantor agency in determining the total amount of the grant.

Section C. Non-Federal Resources

Lines 8-11—Enter amounts of non-Federal resources that will be used on the grant. If in-kind contributions are included, provide a brief explanation on a separate sheet.

Column (a)—Enter the program titles identical to Column (a), Section A. A breakdown by function or activity is not necessary.

Column (b)—Enter the contribution to be made by the applicant.

Column (c)—Enter the amount of the State's cash and in-kind contribution if the applicant is not a State or State agency. Applicants which are a State or State agencies should leave this column blank.

Column (d)—Enter the amount of cash and in-kind contributions to be made from all other sources.

Column (e)—Enter totals of Columns (b), (c), and (d).

Line 12—Enter the total for each of Columns (b)-(e). The amount in Column (e) should be equal to the amount on Line 5, Column (f) Section A.

Section D. Forecasted Cash Needs

Line 13—Enter the amount of cash needed by quarter from the grantor agency during the first year.

Line 14—Enter the amount of cash from all other sources needed by quarter during the first year.

Line 15—Enter the totals of amounts on Lines 13 and 14.

Section E. Budget Estimates of Federal Funds Needed for Balance Project

Lines 16-19—Enter in Column (a) the same grant program titles shown Column
(a), Section A. A breakdown by function or activity is not necessary. For applications and continuation grant applications, enter in the proper colu amounts of Federal funds which will be needed to complete the progran project over the succeeding funding periods (usually in years). This sect need not be completed for revisions (amendments, changes, or supplen funds for the current year of existing grants.
If more than four lines are needed to list the program titles, submit addit schedules as necessary.

Line 20—Enter the total for each of the Columns (b)-(e). When addition schedules are prepared for this Section, annotate accordingly and show overall totals on this line.

Section F. Other Budget Information

Line 21—Use this space to explain amounts for individual direct object-cost categories that may appear to be out of the ordinary or to explain th details as required by the Federal grantor agency.

Line 22—Enter the type of indirect rate (provisional, predetermined, fina fixed) that will be in effect during the funding period, the estimated amou the base to which the rate is applied, and the total indirect expense.

Line 23—Provide any other explanations or comments deemed necess

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Mid-Atlantic Clean Hydrogen Hub
Summary for Public Release

Name of applicant: Mid-Atlantic Clean Hydrogen Hub, Inc.

Program/project manager: Martin R. Wade III

Project title: Mid-Atlantic Clean Hydrogen Hub (MACH2)

Description of project

The Mid-Atlantic Clean Hydrogen Hub (MACH2) proposes to establish a clean hydrogen hub that will connect clean (largely green and pink) hydrogen producers and potential clean hydrogen consumers via connected infrastructure located within the Mid-Atlantic Region of the US. Specifically, the hub will encompass the entire state of Delaware and the regions of Southern New Jersey and Southeastern Pennsylvania which border the Delaware River, extending from Delaware City, DE to the south to Trenton, NJ to the north – the I-95 corridor that is home to nearly 4 million people and numerous manufacturing, chemical and bioscience companies.

Specifically, the MACH2 aims to:

1) Generate clean and predominantly zero-emission green and pink hydrogen to fuel the local energy economy while mitigating emissions;

2) Reuse and revitalize significant existing pipeline infrastructure in a formerly industrialized and still densely populated region;

3) Create and retain more than 20,000 well-paying union jobs and generate a new talent pipeline in the clean energy sector; and

4) Provide economic opportunity and health improvements that will directly benefit historically underserved communities, in alignment with the President's Justice40 initiative objectives.

Throughout the Mid-Atlantic region, there are multiple producers, distributors, and users that are not only internally connected via existing pipelines and rights-of-way, but also link via existing regional pipelines to geographic locations beyond this three-state hub, positioning our network for potential future expansion and network connectivity across Northeastern, Southeastern, and Midwestern regions.

The legacy of petroleum refining and chemical production in the Mid-Atlantic region has left significant connective infrastructure for the production and conveyance of liquids and gases. Within the hub's geographic area, there were seven large refineries operating in the region until 2011, three of which are still in operation today. Because of this, there are multiple unused pipelines ready to be converted to hydrogen use, four existing large underground storage caverns, multiple connected terminals with above-ground storage for gases and liquids, and multiple truck loading facilities to transport gases and liquids. The geography features industrialized port cities in PA, DE, and NJ that offer rail and marine logistics and a diverse array of hydrogen consumers enabling this new industry to develop in our region.

Due to this long-established energy industry, the Mid-Atlantic region also boasts an existing highly trained unionized workforce that has a depth of experience in the construction and operation of cryogenic and pressurized fuel facilities, making this region geographically advantageous for the development of a clean hydrogen hub which will contribute to a national clean hydrogen network across the US.

MACH2 stands to positive impact the Mid-Atlantic region and the US as a whole in the following ways:

1) The regional talent pipeline will be developed to support a clean hydrogen workforce, including the upskilling and re-skilling of new and existing technicians and trade workers;

2) The hydrogen transition will support environmental justice goals such as reducing carbon emissions and air and water pollution in disadvantaged communities; and

3) Hydrogen producers, storers, transporters, and users will have the ability to leverage this historic investment to accelerate their own organizational net-zero and sustainability goals.

MACH2's key project partners are:

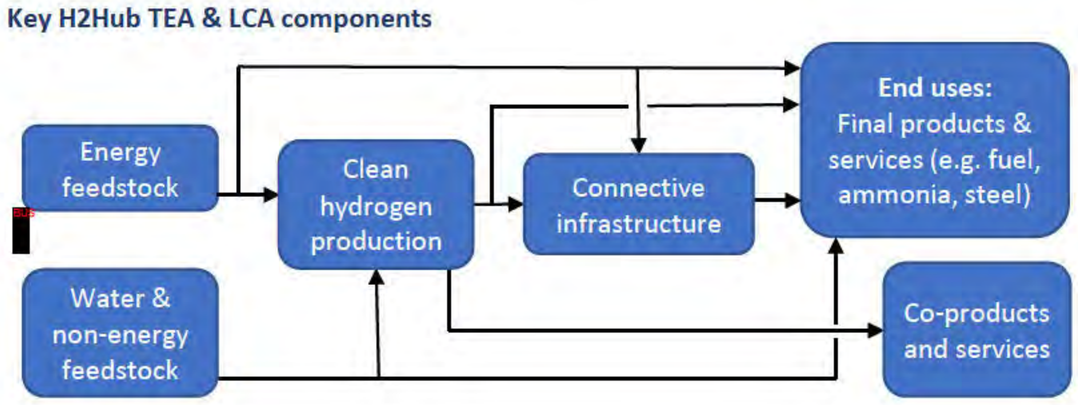
Chesapeake Utilities
Croda
Delaware Area Rapid Transit (DART)
Dupont Experimental Station
Hilco Redevelopment Partners
Holtec
Messer Industrial Gases
Monroe Energy
Philadelphia Gas Works (PGW)
PBF Energy
PSEG
Southeastern Pennsylvania Transportation Authority (SEPTA)
sHYp
University of Delaware
Versogen

Sheet color codes
user input
optional user input
information only; do not modify
ⓘ pop-up information available when cell is clicked
0 quick walk-through section indicators

Summary

In order to effectively evaluate the economic viability and emissions profile of each proposed H2Hub on a common basis, DOE has developed these worksheets to capture parameters associated with the hydrogen production process and of the H2Hub as a whole. The figure below provides a general layout of accounting for the H2Hubs. Clean hydrogen producers as well as hydrogen consumers may have multiple economic value streams. For example, an electrolysis-based clean hydrogen producer may provide hydrogen, but also oxygen, low-grade heat, and grid ancillary services. Applicants should provide core parameters associated with their H2Hub as well as the magnitude of expected co-products.

Key H2Hub TEA & LCA components



Preferred and ambiguous units clarifications ⓘ

Measurement	Preferred units
Hydrogen	kg, kg/day
Ammonia	m.tonne
Natural gas, LPG	mmBTU, HHV
Coal	m.tonne
Biomass	m.tonne
Note: please provide BTU LHV and HHV content of woody biomass	
Diesel, gasoline, oil	gal
Electric energy	kWh
Electric power	kW
Distance	miles
Area (land)	acres
Volume	m^3
Energy for thermal	mmBTU, LHV

Mass-based:

m.tonne	metric tonne (1,000 kg)
MMT	million metric tonnes
KMT	thousand metric tonnes

Volume-based:

Nm^3	normal cubic meter (at 0°C, 1.01325 bar); used for gasses. Use m^3 for incompressible liquids.
SCF	standard cubic foot (at 60°F, 14.73 psia); used for gasses. Use ft^3 for incompressible liquids.
MMCF	million standard cubic feet
barrel	42 gallons

Note: if combustibles which may have different volumetric heat content are specified, please provide energy density (e.g. biogas BTU/SCF)

Energy-based:

kWh	use this unit for electricity only. if combustible product is quantified, use units subscripted with .LHV or .HHV basis when using kWh
.HHV	energy unit suffix designating lower-heating value which applies to combustible streams
.LHV	energy unit suffix designating higher-heating value which applies to combustible streams

H2HUB SUMMARY METRICS

CLEAN HYDROGEN PRODUCTION

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

H2HUB DETAILED INPUTS

MAJOR EQUIPMENT LIST & DESCRIPTION

1 Provide up to 10 itemized H2Hub components - e.g. electrolyzer, compressor, pipeline, ammonia plant, truck terminal, tractors, trailers etc. Also provide initial and final value of any non-depreciable items.

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Non-depreciable items value at end of analysis period	$ -

H2HUB PRIMARY COMMODITY PRODUCT

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

3 Fill out annual sales projection and price for primary hub product. Please factor in any capacity factors, start-up ramp rates, maintenance down-time allowances etc. In absence of specific price [redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

H2HUB MAJOR CO-PRODUCT VALUE STREAMS

[redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

H2HUB ENERGY / FEEDSTOCK INPUTS

6 Provide up to 10 energy or non-energy feedstock specifications for H2hub inputs. Those should be reported on **per-unit of primary hub output**. For example, if a hub comprises solely of an electrolyzer, it would require water and electricity. Those may be specified as Feedstock name = water, feedstock units = gal, feedstock use rate = 5. Feedstock name 2 = electricity, feedstock 2 units = kWh, feedstock use rate = 54. If the hub has other non-energy inputs that are known and substantive please describe as well e.g. catalysts, chemical feed etc. Non-energy hub inputs can be specified with a nominal 2025 cost estimate and [redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Project Title: Mid-Atlantic Clean Hydrogen Hub (MACH2)	
Exchange Control Number: 2779-1593	Geographic Region: Mid-Atlantic
Prime Applicant: Mid-Atlantic Clean Hydrogen Hub, Inc.	
Sub-Recipients/Project Partners Chesapeake Utilities, Croda, DART, DuPont Experimental Station, Enbridge, Hilco Redevelopment Partners, Holtec, Messer Industrial Gases, Monroe Energy, PBF Energy, PGW, PSEG, SEPTA, sHYp, University of Delaware, Versogen	
Do the proposed prime recipient and <u>all</u> subrecipients qualify as domestic entities*? ☒ Yes ☐ No If not, which entities will require a foreign entity waiver: n/a	* To qualify as a domestic entity, the entity must be organized, chartered, or incorporated (or otherwise formed) under the laws of a particular state or territory of the United States; have majority domestic ownership and control; and have a physical place of business in the United States.
H2Hub Program/Project Manager: Marty Wade MACH2 CEO	[redacted]
Business Contact: Dora Cheatham MACH2 Board Secretary	[redacted]
Confidentiality Statement: n/a	
H_2 Production Capacity: *(metric tons H_2/day)* *271*	Total Period of Performance: *10 years*
Total H2Hub DOE Funding Request: *($M USD)* *839*	Total H2Hub Non-Federal Cost Share: *($M USD)* *2,191*

For each category, please select all that apply:

<u>Energy Feedstock:</u>

☒ Renewables: solar / wind
☒ Nuclear
☐ Fossil fuels
☒ Other: RNG / BioGas for SMR with CCUS

<u>End-uses:</u>

☒ Electric power generation
☒ Industrial *(e.g., ammonia, steel, synthetic fuel production)*
☒ Residential or commercial heating
☒ Transportation
☐ Other: ______________________________

<u>Production Technologies:</u>

☒ Electrolysis
☒ Thermal conversion *(e.g., reforming, gasification, pyrolysis)*
☐ Other: ______________________________

<u>Connective Infrastructure:</u>

☒ H_2 pipelines
☒ H_2 carriers
☐ Underground H_2 storage
☒ Above ground H_2 storage
☒ H_2 fueling stations
☐ Other: ______________________________

Contents

Part 1: Business Development and Management

H2Hub Summary

The Mid Atlantic Hydrogen Hub (MACH2) was established in January 2023 as a 501(c)(3) non-profit for the purpose of developing a regional clean H_2 hub that will connect hydrogen producers and consumers within the Mid-Atlantic Region of the US, namely the state of Delaware, Southern New Jersey and Southeastern Pennsylvania. As you will see throughout this application, the MACH2 Hub is well positioned to take advantage of DOE funding and significantly contribute to the advancement of clean H_2 across the US. Strong regional production and demand numbers well above the FOA minimum requirements, along with a competitive LCOH of $3.86/ kg with DOE funding set the stage for the rapid development of a hydrogen market. MACH2 has a broad network of existing pipelines that will serve as the backbone of the Hub and can eventually be leveraged for further expansion. Moreover, given its production technology mix, MACH2 will produce clean H_2 with an expected average carbon intensity -0.17 kg CO2e/ kg H_2 2024-2035, with all individual project emissions expected below 0.45 kg CO2e/ kg H_2, thus, receiving the full $3/kg clean H_2 Production Tax Credit. Lastly, its proximity to important innovation centers as well as its partnerships with regional educational institutions put MACH2 in a prime position to develop holistic training programs and implement its robust community benefits plan.

MACH2 aims to become an engine for growth in the region and drive the creation and retention of 13,000 to 20,000 well-paying jobs in the low carbon economy, as well as generate a new talent pipeline in the sector through collaboration with unions, universities and community colleges and regional workforce development boards. Moreover, MACH2 will provide economic opportunity, access, and health improvements to directly benefit historically underserved communities in alignment with President Biden's Justice40 objectives, in a region with a preponderance of disadvantaged communities.

MACH2 has worked with partners to define its high-level schedule in line with DOE guidance, shown in Figure 1. Hub schematics can be found in the Commercial Feasibility section on Figure 3: Overview of MACH2 hub projects and infrastructure in Philadelphia and South Jersey and Figure 4. MACH2 has been led by an Interim Leadership Team with the qualifications, experience, and stakeholder relationships necessary to build the framework, vision, and roadmap for the Hub. MACH2 will be led by a Board of Directors (BOD) that will include government representatives from all 3 regions mentioned above, as well as representatives from industry, academia and labor described in detail in the management section. This BOD will hold all fiduciary responsibility for the organization, while an Executive Team reporting to the BOD will be accountable for executing the hub plan and meeting milestones, budgets and strategic goals.

Figure 1: MACH2 high-level schedule

MACH2 has over 20 project partners actively committed to the production, transportation, and consumption of clean H_2. All partners have been carefully selected and are financially sound organizations with significant experience implementing large capital projects. To demonstrate this, each partner submitted a commitment letter detailing their commitment to decarbonization and the MACH2 Hub. MACH2 will produce clean hydrogen at an expected rate of 170 mtpd[1] by end of Phase II (well over the 50-100 mtpd FOA requirement), reaching a production of 271 mtpd by 2032. On the demand side, the MACH2 hub is expected to reach 338 mtpd by 2032 through a variety of end uses described below and detailed throughout the volume. The overall relative balance between supply and demand indicates both a strong appetite from regional off takers and the makings of a competitive market.

Production of the Hub is primarily composed of pink and green H_2 projects, with a single 7.5 mt/day orange H_2 project (RNG w/ SMR and CCUS). Identified projects use a variety of proven commercialized technologies such as PEM as well as innovative technologies that will reach TRL 8 by the end of the award period such as AEM and membraneless electrolyzers. Reusing and revitalizing existing pipeline infrastructure is a key component of the MACH2 Hub and was a driving influence in the selection of site locations. Detailed throughout the TEA, each site is on an operating or formerly operating industrial or chemical site with access to existing pipelines. Siting at these locations allows MACH2 to leverage its historically strong industrial presence, highly trained unionized workforce, and extensive existing pipeline infrastructure with rights of way, and easements to establish economic hydrogen distribution paths. MACH2's core H_2 transportation will take place via a 50-mile "open stock" pipeline network connecting multiple producers with end users and supplemented with truck delivery to support "last mile" delivery. Finally, within MACH2's geographic area, there are three large refineries in operation today that are key MACH2 partners and demand offtakers in the early phases; they plan to use H_2 as a replacement fuel in their industrial boilers and other fired equipment. Their demand will be complemented with end-users from the transportation and power sector, rounding off MACH2's expected demand. Targeting these large, concentrated, hard to electrify off takers enables both economies of scale and the greatest impact in overall decarbonization efforts. As described in the Growth Plan section, the Hub envisions growth potential both in supply and demand beyond the currently committed project partners.

[1] Metric tons per day

MACH2's total estimated costs amount to ~$3B, with a request for DOE funding of $839M. The requested investment of $839M from the DOE to establish MACH2, together with an overall greater than 70% cost share, will enable the economic viability of MACH2 projects and the acceleration of hydrogen production, contributing to the decarbonization of the region and driving the transition towards low carbon hydrogen. MACH2 expects a competitive production LCOH by 2030 of $3.86/kg H2 with DOE funding, well below the range of prices demand partners are willing to pay for low carbon hydrogen. Without DOE funding, LCOH's would increase by up to $1 per kg increasing the difficulty of finding offtakers willing to purchase at this higher price. With DOE funding during the award period, MACH2 is confident it will be able to attract follow on private investments beyond the award period due to attractive future at-gate hydrogen prices, strong regional presence of additional potential off-takers, and legacy of energy production within the Hub that reduces capital by repurposing underutilized assets. The abundance of existing infrastructure and needed feedstock resources reduces overall hydrogen delivery costs, gives MACH2 a clear scale-up advantage and an opportunity to further attract investments in new demand segments and hub regions.

The current production mix makes MACH2 a carbon negative hub with estimated CO_{2e} well-to-gate emissions reaching an average of -0.17 Kg CO2e/ Kg H2 2024-2035, strongly supporting decarbonization efforts of end-users. MACH2 is well positioned to expand its geographical footprint through existing underutilized pipelines, as well as to capture demand growth in future end-uses, such as heavy-duty transport, aviation and shipping. Potential demand from these industries can be accessed through MACH2's regional SAF production, world renowned airports, train and trucking infrastructure, as well as its proximity to prominent ports. Additionally, MACH2 has engaged the support of regional educational institutions to develop training programs and support community outreach. Demonstrated above and throughout the technical volume, MACH2 holds a unique position to contribute to a national hydrogen strategy. Its dense and underutilized transportation infrastructure, geographically concentrated large offtake partners, abundance of feedstock, and strategic proximity to important innovation centers are primed for large scale hydrogen adoption through the catalyst of DOE funding.

Business Plan

Commercial Feasibility

Summary: In alignment with this FOA, MACH2 will produce clean hydrogen at a minimum rate of >50-100 mt per day by Phase II using commercially available tech while also leveraging key infrastructure and industries in the area. 100% of production from Phases I-II are from commercial technologies at TRL of 9 or higher (e.g., PEM electrolysis and SMR w/ RNG), with innovative technologies at TRL 5/6 expected to come online and reach commercial scale by Phase III (AEM, membraneless electrolysis). Similarly, all end uses in early phases are based on commercially mature technologies at "market uptake" TRL levels, being composed of a mix of hydrogen combustion as replacement fuel for fired equipment, or transportation end uses based on H_2 fuel cells (TRL 8 for heavy duty vehicles[2]). Key partners have historically large

[2] IEA ETP Clean Energy Technology Guide

industrial presence in the area (e.g., Monroe, Hilco) and own existing infrastructure, as well as easements or rights of way (ROWs) for ~44 miles of important pipeline infrastructure (e.g., PBF, PGW) to transport hydrogen from hub producers to offtakers. This not only increases hub reach but provides an important cost advantage to the Hub. MACH2 has access to a resilient and secure electrolyzer supply chain through Bloom energy and Versogen production facilities in Delaware. MACH2 has a unique position to contribute to a national hydrogen strategy through its strategic proximity to important innovation centers for advancing hydrogen technologies (e.g., University of Delaware's Center for Clean Hydrogen and Air Liquide's innovation center) and cutting-edge technology partners (Versogen, sHYp, SmartPipe).

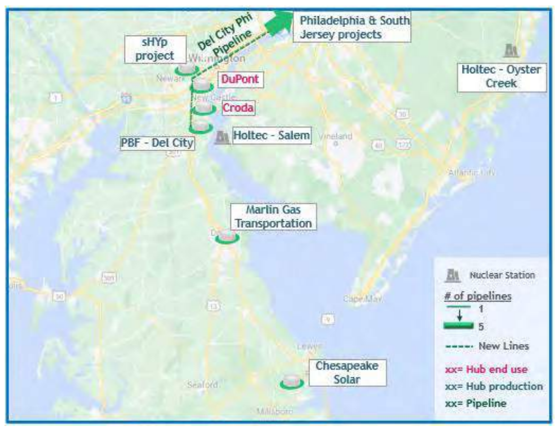
MACH2 will have substantial initial volume production capabilities, as shown in Figure 2, expected as soon as Phase II starts (Jun 2025-Feb 2028). MACH2 is committed to pursuing an appropriate combination of projects for production, distribution, storage, and end use to maintain a strong supply and demand balance to minimize the stranding of assets as elements of the H_2 supply chain are being built. To do this, MACH2 already has proposed projects that plan to commence initial operations by Phases I&II, with a combined production of ~174 mt[3] H_2/day at the end of Phase II. This production level already meets the minimum DOE requirements. Moreover, MACH2 has ambitious sustainability targets and is formed as a green and pink hydrogen hub, with ~97% of production from green and pink sources by 2032. Thus, Phase I&II production is primarily driven by pink and green hydrogen projects, with an additional 7.5 mt/day orange hydrogen (RNG w/ SMR and CCUS) project led by Philadelphia Gas Works (PGW) during Phase II. The pink hydrogen projects combined, led by Holtec and PSEG, account for a production volume of ~39 mt/day by Phase II. The remaining ~129 mt/day production by end of Phase II will be from green electrolysis projects driven by PBF, Enbridge, Versogen, Chesapeake Utilities, Messer, and sHYp. By the end of phase III in 2031, production levels reach ~257 mt/day, through a mix of the aforementioned projects continuing to ramp up to meet their max. Additional projects starting at the end of Phase III and start of Phase IV add further production capacity in addition to the scale up of projects that begin operations in the earlier phases. These are an additional pink hydrogen project at Oyster creek with Holtec and a green electrolysis project with PGW. The hub's primary product will be hydrogen, produced through a mix of 82% green electrolysis, 15% pink hydrogen and 3% orange hydrogen by 2031.

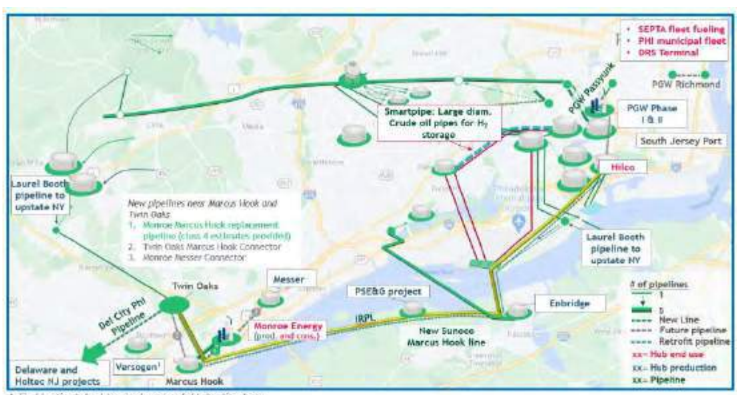
[3] Metric ton

Figure 2: Expected supply and demand in each phase based on project agreements and expected production.

The anchor offtakers in Phases II-III are Hilco and Monroe, which are expected to use ~76mt H_2/day by end of Phase II and ~289 mt/day by end of phase III. Hilco plans to use the low carbon hydrogen at its facilities for power and steam generation through combustion that runs a turbine. Monroe will also use low carbon hydrogen as fuel replacement for their refinery's boiler. Additional demand comes from our various heavy-duty transportation focused offtakers like SEPTA, Philadelphia's municipal fleet, and Delaware River Stevedores (DRS) Tioga terminal. These offtakers account for ~8 mt/day by the end of Phase II, scaling up to ~16 mt/ day by end of Phase III and at build-out will replace over 1600 diesel vehicles with hydrogen fuel. Lastly, the remaining demand is allocated to industrial players like Croda and DuPont Experimental Station where they will substitute and use hydrogen as replacement fuel for their fired equipment, burners, and boilers. The projects and partners involved in MACH2 have presence in Delaware and the regions of Southern New Jersey and Southeastern Pennsylvania that border the Delaware River. Figures 3 and 4 show how the hub partners and geography are laid out.

Figure 3: Overview of MACH2 hub projects and infrastructure in Philadelphia and South Jersey





1. Final location to be determined; most probable location shown

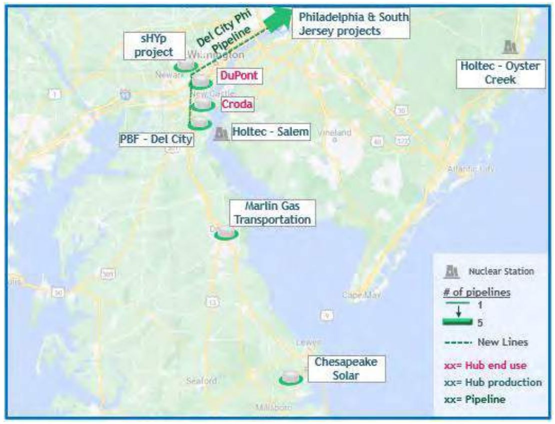


Figure 4:Overview of MACH2 hub projects in Delaware and South Jersey

Supply: MACH2 is also appropriately balancing commercial feasibility in the short term with investments in promising technologies for future hydrogen production and the advancement of clean energy tech. Thus, the majority of the technologies used in the hub are already commercially viable and have high technical feasibility and competitiveness. Orange hydrogen (H_2 from SMR using RNG/biogas with carbon capture) is already commercial, and electrolysis from PEM and Alkaline are at a TRL level of 9, with commercialization and early adoption already in place[4]. Furthermore, MACH2 will also be utilizing solid oxide electrolyzers (SOECs) and anion exchange membrane electrolyzers (AEM) for green hydrogen production, which EIA currently designates as TRL level 7 for SOEC (pre-commercial demonstration) and 6 for AEMs (full prototype at scale), but that are expected to reach TRL level 8 by end of award period[4]. SOECs are more efficient than PEM and AEM electrolyzers, but they operate at high temperatures and require a source of heat (e.g., waste heat or nuclear energy). However, this means they are an attractive option for integration into onsite hydrogen generation for many heavy industrial and chemical processes and an important area to invest in for future commercialization efforts. Bloom Energy will be supplying MACH2 with SOECs for multiple projects, having already demonstrated in other instances the use of their SOECs to produce hydrogen using nuclear and in marine applications[5]. PSEG Renewable Ventures LLC is also committed to providing a PPA for nuclear power generated from the Salem or Hope Creek nuclear generating stations, which is advantageous given SOEC's unique operating conditions making it very suitable for co-location next to a nuclear site. AEM electrolyzers build off more traditional alkaline electrolyzers but are safer to handle, given they can operate in a more diluted alkaline environment. They also use nonprecious metal catalysts, greatly reducing their cost. They can respond more quickly than traditional alkaline electrolyzers, reducing ramp up time to production, making them suitable to a wide range of applications needing more on demand fuel or power supply[6]. Versogen has submitted a project with MACH2 using their AEM technology, having also recently secured funding to expand their manufacturing capacity in Delaware. MACH2 and the various partners have been in discussions with Bloom Energy to be

[4] IEA
[5] Bloom Energy
[6]IRENA

the provider of SOEC electrolyzers. The diversity of multiple manufacturing methods and end-uses is another way in which MACH2 can ensure long term hub feasibility.

As mentioned, in Phases I and II, a mix of pink and green hydrogen will be the main sources from which the hub achieves market liftoff. A small orange hydrogen project, driven by steam methane reforming (SMR) from renewable natural gas (RNG)/biogas, will come in line in Phase I that does not significantly affect the Hub's production mix at a total production of ~7.5 mt H_2/day. The project, run by Philadelphia Gas Works will also include carbon capture to further reduce the project's carbon intensity from 0.2 to -6.5 kg CO_{2e}/kg H_2[7]. Holtec will be producing pink hydrogen through their Salem creek nuclear site for a production of ~14 mt/day starting in Phase II. Additionally, they have plans to increase pink hydrogen production at their Oyster creek site with an additional ~14 mt/day initially in 2032 through completion of a small modular reactor of 160 MW (with additional offshore wind power). PSEG has also proposed a pink hydrogen project starting in 2027 or Phase II for an additional production volume of 25 mt/day. Thus, the total pink hydrogen production volume of MACH2 is expected to be ~53 mt H_2/day by 2032. Some small-scale green hydrogen projects from startups sHYp and Versogen plan to begin in phases I and II but are only expecting to produce small amounts of hydrogen at the beginning, to focus on increasing their technology's TRLs of 5/6 to 8 by end of the award period. sHYp is investigating a site near the port of Wilmington in conversations with Ameresco, where they would build solar to power sHYp's operations next to their Pigeon point site. Versogen plans to build their site in the Marcus Hook area to take advantage of the available infrastructure to reduce CapEx needs by taking advantage of the existing pipeline and facilitate access for the various demand offtakers. These small-scale projects are expected to reach TRLs of 8 and have ramped up their operations by Phase IV in 2031, expected to produce ~68mt/day.

In the medium to long term, electrolysis will be used to produce the majority of MACH2's low carbon hydrogen. PBF, Enbridge, Messer, PGW, Chesapeake utilities, and Versogen are the hub's primary producers of green hydrogen. Versogen and Bloom Energy will be providing the majority of the electrolyzer equipment and are a key advantage for MACH2, given they both have production facilities already located in Delaware, increasing the security of acquiring electrolyzer capacity more quickly and on schedule. Siemens and NEL have also been vetted as additional proposed vendors for PEM and AEM electrolyzer projects proposed. To accommodate the electricity production for the green electrolysis projects, approximately 1.7 GW of renewables will be built or secured via long term PPAs at an expected average electricity price of $60-90/MWh. The green H_2 electrolysis technologies used will be PEM, AEM, and membraneless electrolyzers with sea water, which in total are expected to produce 210 mt/day by 2032 (67% PEM, 31% AEM, 2% membraneless).

Demand & infrastructure: Within MACH2's geographic area, there are three large refineries still in operation today and are key MACH2 hub offtake and hydrogen infrastructure partners (PBF refineries at Delaware city and Paulsboro and Monroe Energy). The produced hydrogen will be allocated to these offtakers, with specific commitments expected to be reached with specific producers in Phase I. All the MACH2 partners in consideration have submitted letters of commitment to MACH2. Conversations with additional large emitter private sector partners in

[7] See LCA section of TEA for details on assumptions and calculations using the GREET model

the steel and cement sectors are also in progress as potential additional offtakers to build an even more robust customer base (e.g., Cleveland Cliffs, BuzziUnicem, etc.) As mentioned earlier, Hilco and Monroe energy will be the key offtakers in the short term with a combined demand of ~76 mt/day by end of first two phases and ramping up to a demand of ~289 by Phase III. However, additional demand will also come from the transportation and power sector in the medium to long term. SEPTA, DRS Tioga terminal fleets and the City of Philadelphia's municipal fleet will all take a smaller amount of the hub demand, ~8 H_2 mt/day total in the first couple of phases, expecting to switch over their entire fleet over a ~10-year period. SEPTA has already secured additional grant funding for two projects that are already underway. One project includes the purchase of ten 40' fuel cell electric buses, a mobile hydrogen storage/fueling system, and the required bus depot building modifications needed to maintain/service the ten buses (2018 FTA Fuel Cell Electric Bus Demonstration Fleet Grant). The second project is for the construction of permanent hydrogen fueling infrastructure, both storage and dispensing (FTA Infrastructure Preparation grant 2020). DuPont is planning a project to convert their boilers over to hydrogen with demand starting as early as Phase I, with 2 mt H_2/ day. By Phase II, Croda also plans to transition their process burners from Natural gas to Hydrogen to receive hydrogen at 2 mt/day.

Additionally, due to the long-established energy industry and industrial presence, there are multiple pipelines ready to be converted to hydrogen-suitable pipelines, multiple connected terminals with above-ground storage for gases and liquids, and multiple truck loading facilities to transport gases and liquids. MACH2 plans for its core H_2 transportation to take place through a 50-mile pipeline network connecting multiple producers with end users and supplemented with truck delivery to supply users located away from the pipelines. The Hub plans to use existing infrastructure, easements and rights of way from PBF, Chesapeake Utilities, PGW, and other midstream companies for replacement and refurbishment of existing pipeline routes. Given the extent of existing infrastructure and permanent easements already controlled by Hub participants, MACH2 holds a significant competitive advantage. The primary pipeline system will be formed by two projects. First, a new 24-mile gas-phase hydrogen pipeline is planned to be built with a 150 mt/day capacity and will connect production from Delaware City Refining Company LLC site to the northern section of the hub via a new Inter-refinery pipeline (IRPL). Second, a new 24-mile IRPL line that can transport approx. 150 mt/day of hydrogen will be dug out and laid, transiting from Marcus Hook, PA, via New Jersey to Philadelphia, with permanent existing easements. These projects will connect the entire north-south axis of MACH2.
In addition, smaller pipeline projects of less than 2 miles may also be constructed to optimize distribution and improve connectivity between producers and end-uses.

In total, MACH2 expects a total of ~11 miles of new pipelines needed along permanent easement routes, given the area's long existing industrial corridor. This includes a 5 miles connector from Marcus Hook to Twin Oaks, PA, a potential 1-mile pipeline from Monroe to the Messer site in PA, and additional connecting lines to projects in the area which are detailed in the hydrogen transportation projects portion of the technoeconomic analysis section. Buckeye pipeline also has extensive 20 in. underutilized pipelines that can be refurbished to transport hydrogen and there are networks of out of service crude oil pipelines near Sunoco that can be refurbished for H_2 storage and transport. [redacted] is a non-intrusive, high-pressure reinforced thermoplastic pipeline technology that can be pulled through existing pipe in long lengths (multiple miles). The technology has embedded fiber optics that provide continuous safety monitoring and has been reviewed by the DOE for H_2 transmission, with operations and processes in place to have permits for deployment ready by 2024. For alternative storage, MACH2 is investigating the use of above ground pressurized storage with estimated costs around ~$1M/mt H_2 at various project sites. With the existing infrastructure available within the MACH2 region that can be repurposed, and a low carbon footprint and reduced environmental impact, this technology can greatly improve the safety of existing pipelines. PGW and Chesapeake are focusing on connecting production sites to H_2 transit fueling stations, SEPTA transit hubs and the Tioga marine yard. [redacted]

Overall, using existing pipeline infrastructure, rights of way, and easements is inherently less risky, allowing the hub to successfully ramp up and meet expected hydrogen production and demand early on. Pipeline transport provides the most economical distribution and enables expansion to surrounding regions with additional mature captive industrial demand as the hub grows. Furthermore, the MACH2 region boasts an existing highly trained unionized workforce from the industrial sector that has a depth of experience in the construction and operation of cryogenic and pressurized fuel facilities, making this region geographically advantageous for the development of a clean hydrogen hub.

Advancement and further commercialization: MACH2 is also uniquely positioned to contribute to building out a national clean hydrogen network through its existing infrastructure. Not only is having electrolyzer production localized to Delaware with Bloom Energy and Versogen a huge advantage, given local supply and minimizing supply chain risk, but once MACH2 is established, existing, large diameter pipelines utilizing the Buckeye Network may be modified using Smartpipe's technology to expand MACH2's geographical reach throughout the Delaware Valley, to Ohio and to New York Harbor to connect with other hubs. Our hub has access to existing underutilized pipelines that can connect MACH2 as well to Rochester in upstate NY and from NYC to Linden. An example of this network is illustrated in Figure 5.

Figure 5: Example map of pipeline infrastructure in region outside of MACH2, with access to upstate NY

MACH2's location provides strategic proximity to prominent clean energy academic institutions and industrial strongholds offering a unique opportunity to advance future use cases of H_2 and invest in commercialization of more immature technology expected to see high future demand**:**

- The Center for Clean Hydrogen at the University of Delaware, a partnership between the University of Delaware, Chemours, Plug Power, and the National Renewable Laboratory, is a 25,000 sq.ft., state of the art facility with a mission to help accelerate the energy transition by providing electrolyzer stack and components testing at the commercial MW scale. The Center anticipates helping MACH2 partners advance their technologies by providing hydrogen stacks and components services. The Center also conducts cutting edge research, trains clean hydrogen workforce, and spins out hydrogen startups. The specific goal of its research is to reduce the cost of green hydrogen by developing low-cost materials, new stack designs, and fast manufacturing methods.
- Air Liquide's innovation center in Newark, DE will help test incipient technologies and accelerate ramp up.
- The DE Sustainable Chemistry Alliance (DESCA) will help increase awareness of opportunities in H2 by convening stakeholders across industry, academia, government, CBOs and the regional community.

Incentives & policy: The MACH2 region itself has a very favorable legislative and policy environment for clean energy, with all hub states pushing to reshape their economy to a lower carbon one by 2050 through their respective climate action plans[8]: PA's Climate Change Act requires the state to reduce its GHG emissions to 80% below 2005 levels by 2050 and 26% by 2025; NJ's Global Warming Response Act requires the state to reduce its greenhouse gas emissions to 80% below 2006 levels by 2050; and DE's Climate Change Solutions Act would set targets of reducing emissions by 50% from 2005 levels by 2030 and 90% by 2050.

In addition to the generous federal incentives set forth in the IRA and IIJA for hydrogen production (e.g., $3/kg for production methods 0-0.45 kg CO_2/kg H_2), there are state incentives that the hub can access for additional investment and expansion: PA is offering $0.81/kg H2 and $0.47/mcf natural gas purchased for use in manufacturing at a facility part of a Regional Clean H_2 Hub; comes into law Jan 2024[9], and PA and NJ also offer zero emission vehicle (ZEV) incentives which include fuel cell vehicles. This could benefit some of the MACH2 transportation-focused projects, such as SEPTA, DRS, or the municipal fleet of the city of Philadelphia.

Key Contracts, Permits, Agreements:

MACH2 has many interested parties at varying levels of commitment and project readiness. All partners have submitted letters of commitment. The expected critical path contracts, permits and agreements we expect for our hub and partners is shown below in Table 1 and encompass primarily the permitting needed to begin construction for the various proposed projects, as well

[8] PA.gov; NJ.gov; Delaware.gov

[9] Qualification for this incentive in PA may be subject to applicants being able to create more than 1,200 jobs as result of their activity.

as the feedstock (energy and electrolyzer suppliers) and offtake agreements. This list is non-exhaustive and subject to change as projects and the hub advance across phases. PSEG cannot share written rate information due to its competitive nature, but we have been in active discussions for their partnership across partners. A more comprehensive description of expected permitting needs by project partner can be found in EPC and the safety, security, and regulatory requirements sections that follow. The below table is only to give a broad overview and synthesizes common status among the more than 20 partners composing the MACH2 hub.

Table 1: High level key contracts, permits and agreements.

Critical path items	Schedule (project dependent)	Status
Site selection and MOUs in place	To be completed by end of phase I	In progress
Production and offtaker contracts	To be completed by end of phase II	In progress
Ground lease permits & site access secured	To be completed by end of phase II	In progress
PPA and electricity feedstock contracts	To be completed by end of phase II	Conversations started
NEPA/EPA/Environmental permits for sites and waste streams	To be completed by end of phase II	Not started
City/local construction permits	To be completed by end of phase II	Not started
State level construction permits	To be completed by end of phase II	Not started
Bulk handling permits	To be completed by end of phase II	Not started
NFPA hydrogen permits and certifications	To be completed by end of phase II	Not started
PHMSA/DOT pipeline permits and regulatory approval	To be completed by end of phase II	In progress
OSHA and state and local government hydrogen safety permits and certifications	To be completed by end of phase II	Not started
Pipeline right of way (ROW) acquisitions	To be completed by end of phase II	In progress

Preliminary Site Selection: In designing MACH2, site selection was a major factor identified in its future success. MACH2 has a competitive advantage in that most partners that submitted projects either have control over their project sites or are working with other partners that have available land to offer as a project site. The projects proposed for pipeline or delivery of hydrogen are also either already controlled by our partners with rights of way or have permanent easements in place which significantly reduces risk for new pipeline construction. While certain risks in retrofitting or laying down new hydrogen pipeline are unavoidable, MACH2's partners' experience and design put MACH2 in a good place to minimize and mitigate them. Specifics on site selection can be found in the TEA analysis across the specific projects.

Market Analysis

Summary: The Mid-Atlantic region, and specifically PA, NJ, and DE account for 7% of current dollar GDP in the U.S., 43-46% of their population are in the 19–55-year range and are a key part of the workforce, with the clean energy economy accounting for 1.2-1.7% of these states' employment in 2019 and an expected increase of ~30-200% across all states by 2030[10], offering a huge opportunity to drive the creation of well-paying jobs for a low carbon economy and increase US competitiveness. MACH2 is well positioned to take advantage of key economic and

[10] Bureau of Economic Analysis; KFF 2021. PA: 97k jobs in '19 and expected to add 27k by 2030 for 28% increase, NJ: 55k jobs in '19 and expected to add 37k by 2030 for 67% increase, DE: 4.7k jobs in '19 and expected to add 10k by 2030 for 213% increase

market drivers in the region while also leveraging the hub's overall attractive levelized cost of hydrogen (LCOH) to drive competition and demand.

- Key demand drivers for MACH2 region are in gas-to-power, refining, steel, cement, and glass, with high clean hydrogen demand scenario for PA, NJ and DE expected to reach ~665 ktpa by 2035, with projected MACH2 production capturing ~15%.
- PA and NJ have abundant nuclear power for pink hydrogen production (13% of US generation) and MACH2 region has high water availability to support a large increase in green hydrogen production (equivalent to water consumption of 1% of total population of Philadelphia). In addition, all states participating in the Hub's region have ambitious climate action plans to reshape their economies to a lower carbon one by 2050, supporting any development of new renewable electricity generation capacity.
- MACH2 LCOH by 2030 is expected to be \$3.86/kg H_2 which is below the average delivered \$4-5/kg range prices our partners on average are willing to pay for low carbon hydrogen, even after adding in an average transportation cost of \$0.5-1/kg H_2. This competitive advantage from our low LCOH is expected to drive competition within and outside the hub as demand and production expand.

Demand: The MACH2 region's low carbon hydrogen demand was evaluated in two ways: 1. Current and projected energy consumption across 13 industry sectors and 2. Geographic footprint of large industrial emitters by sector. For the first method, the energy consumption across sectors was converted to relative hydrogen demand based on sector processes and hydrogen use cases. To model projection, expected penetration rates across each sector were then used to determine overall economic demand, which represents the uptake of H_2 when compared to other alternative sources. This allows for an approximate estimation of what the higher and lower bounds of demand for low carbon hydrogen could be out until 2050. As the Figure below shows, total current demand of low carbon hydrogen by 2035E amounts to an expected higher bound of ~665 ktpa across PA, NJ, DE across 13 industrial sectors[11]. In this scenario, MACH2 has the potential to capture ~15% with the currently expected ~100 ktpa (~271 mt/day) 2035 production volumes.

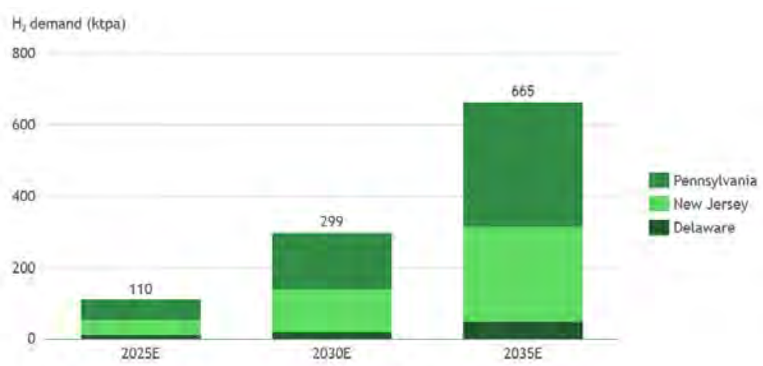


Figure 6: Higher bound of total low-carbon H2 economic potential demand in PA, NJ & DE (ktpa)

[11] EIA; EPA; Sectors include refining, ammonia, cement, coal mining, glass, transport, iron & steel (EAF), iron & steel (BOF), lime, methanol, petchem (excl. MeOH), power plants, glass

It was found that the differentiated demand drivers, defined as industries where there is a higher proportion of demand relative to the US, across the hub region are in refining, steel, cement and glass manufacturing. From this analysis, MACH2 is in the top quartile across all US states for overall low carbon hydrogen demand across sectors[12]:

- SE PA: Top quartile ranking in H_2 demand for gas-to-power, cement, and steel in 2021
- SW NJ: Median ranking in shipping and glass across all states in 2021
- NE DE: PA's proximity to DE offers the ability to take advantage of DE's refinery demand which also ranks in the top half of states across the US

These industries will all be pushed to decarbonize in the coming years, and the concentration of industrial players in these sectors in the Hub's region will drive additional demand and growth for our Hub. In addition to the consumption projection demand view illustrated above, a bottom-up view of potential demand was taken by looking at the top industrial emitters across sectors in the US and is shown on the map in Figure 7. Again, the hydrogen demand could be calculated by converting the emissions to ktpa of hydrogen, with the conversion factor depending on the given sector and process. As expected, the MACH2 hub region has a traditionally strong industrial presence, where 70% of emissions in industry come from gas-to-power and refining, translating to 83% share of captive industrial hydrogen demand in the region, with the remaining demand from the cement and steel sectors.

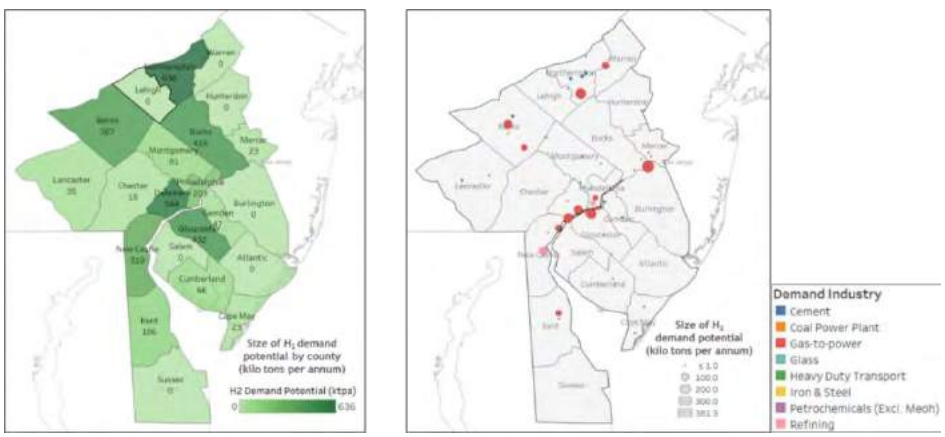


Figure 7: Overview of emitters in MACH2 hub area that could be potential sources of captive industrial H_2 demand.

Feedstock: MACH2 is home to abundant nuclear resources (mainly 2.3 GW Limerick, 2.4 GW Salem, and 1.2 GW Hope Creek). Thus, MACH2 is well positioned to be a differentiated leader in the production of pink H_2. As shown in the commercial feasibility section, the regions within MACH2 also boast strong renewable energy and portfolio targets by 2050. Given the state's natural resources, planned grid energy mix shift to increasingly more renewables, and current federal and state incentives, there are multiple avenues for production of low carbon hydrogen:

- PA and NJ account for ~13% of nuclear energy generation in the US, with 30-40% of their state electricity generation also from nuclear[11].

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[12] EIA AEO, EPA 2019 Emission Inventory, DOE AFDC

- PJM, grid operator for MidAtlantic has plans for 22% of its load to be served by renewables by 2035 to meet its states renewable portfolio standards[13]

In addition, the Hub's region, close to the city of Philadelphia, has access to considerable water resources through the Delaware and Schuylkill rivers, respectively with an average discharge of 13,000 cf/s and 4,700 cf/s. In comparison, an inhabitant of the city of Philadelphia consumes on average 100 gallons per day of water. This means that, at the peak demand of 590M gallons per year in 2032, the water consumption level would be equivalent to the consumption in a year by ~16,000 residents of the City of Philadelphia (1% population), a reasonable increase given water resource availability in the region.

MACH2's portfolio consists of a wide array of projects with diversity of power sources and capacity factors that contribute to an overall competitive levelized cost of hydrogen. As detailed in the TEA, the hub's expected weighted average levelized cost of hydrogen LCOH by 2030 is expected to be \$3.86/kg H_2 which is below the average delivered \$4-5/kg range prices our partners on average are willing to pay for low carbon hydrogen adding in an average transportation cost of \$0.5-1/kg H_2. Overall, the existing agreements, level of enthusiasm from current partners, strong presence of additional potential off-takers, diversity of end uses, existing industrial assets and infrastructure, and skilled union labor give MACH2 a competitive advantage to support the long-term growth of low carbon Hydrogen in the Mid-Atlantic region:

- High population density and resource availability to secure necessary conditions to meet H_2 production and demand.
- Significant potential demand (665 ktpa) for PA, NJ, DE, with hub accounting for ~15% of demand and diversity of end-users, including companies in the electric power generation, industrial, transportation, and commercial sectors.
- Existing infrastructure and assets, interest, and union workforce, enabling the MACH2 region to take on the challenges reshaping the Mid-Atlantic economy to lower carbon H_2 technologies and production.

Marketing and competition: The generous H_2 incentives provided by the IRA for H_2 consumers and natural gas consumption will further increase the Hub's competitiveness and foster demand. Additionally, given strong pipeline and delivery infrastructure partners, MACH2 can ensure a secure and reliable source of hydrogen to new offtakers. All the existing pipelines considered, which amount to around 44 miles, have permanent easements, and will either be replaced, modified, or undergo new line installation within the easement to safely carry H_2. Additional sections amounting to ~11 miles are being assessed by MACH2´s partners.

In the short term, MACH2 hub's production will be primarily consumed by offtakers within the hub. Competition is expected to primarily be within the MACH2 hub driven by projects that compete on out of the gate hydrogen pricing to secure the committed demand from the offtaker partners. Longer term, MACH2 hub's main advantage is lower cost due to existing infrastructure. When local production starts to exceed demand in the area, expected after Phase 4, MACH2 expects to expand its competitive reach to secure additional offtakers. Given MACH2's advantages in refurbishing existing infrastructure, which allows for increasing scale more quickly, MACH2 expects to gain market share through expansion more quickly than other

[13] PJM Energy Transition Frameworks

hubs, while also delivering a cost competitive price of low carbon hydrogen of around ~$3.73/kg by 2040. Given the geographic location and mix of end uses of offtakers within transportation and refining, MACH2 expects to lead in these two sectors as compared to other hubs. In addition, with access to sustainable aviation fuel (SAF) production via Monroe Energy/Delta Airlines, PSEG's Liberty Terminal SAF project, and interest from other large players in the space (American Airlines and United Airlines), MACH2 expects to expand to other major airport hubs in the broader region (e.g., NYC and NJ). The IRPL connects the Philadelphia airport to the rest of the hub operations, with MACH2 potentially able to decarbonize airport ground operations at the Philadelphia airport in the future. As hydrogen for aviation becomes a reality, MACH2 is well positioned to support offtake of SAF across major carriers. Additionally, conversations with NJ Transit will expand MACH2's presence in heavy duty transport and low carbon hydrogen as a potential energy source.

<u>Feedstock, Supplies, Offtake Arrangements</u>

Given MACH2 is primarily a green and pink hydrogen hub, the most important feedstock will be electricity. MACH2 has been in various conversations with Constellation Energy and PSEG as possible partners for securing renewable energy PPA rates. Given the timeline of many projects, we don't expect to have finalized contracts until closer to actual construction starts in Phases I and II. However, for the pink hydrogen projects with Holtec, it is expected their electrolyzers will receive energy as a direct tie in, thus eliminating power distribution costs. Other producers of green hydrogen will be pursuing renewable generation capacity build or PPA agreements (see technoeconomic analysis section). In terms of electrolyzer supply, Bloom Energy (SOEC electrolyzers), Versogen (AEM electrolyzers) and sHYp (seawater electrolysis) have all agreed to provide the technology necessary for their projects directly and have submitted letters of commitment. For the rest of the green hydrogen projects focused on PEM electrolyzers, Siemens and NEL have been identified as potential vendors. However, no official contracts at this stage have been signed, given the very early feasibility stages of these projects. In terms of offtake agreements, MACH2 has received letters of commitment from all of its production and end use/offtake partners. On average, the demand partners have expressed interest and future commitment to buying the hub's hydrogen for a total cost range of $4-5 /kg.

<u>Growth Plan</u>

Summary: MACH2 expects its primarily drive its growth through a combination of future end use case market drivers, regional partnerships, and fostering advancement of innovative tech:

- Transportation end use like heavy duty transport, aviation and shipping will see largest growth in 2040+, with MACH2 well positioned given regional SAF production, world renowned airports, train and trucking infrastructure, and proximity to prominent ports.
- Many companies outside of the present MACH2 hub have expressed a desire to participate in the future to help expand its reach, with those interested spanning Amtrak, New Jersey Transit, Ameresco, PDIC, Bloom Energy, etc.
- MACH2 is also fostering more innovative and early-stage green electrolysis partners like Versogen, sHYp, and Hydropore, whose processes can potentially produce green hydrogen more economically, helping MACH2 continue building its competitive advantage for the region.

Expansion potential: As stated in the marketing and competition section, MACH2 expects that its growth will be driven primarily through the hub's cost competitive price of low carbon hydrogen of around ~$3.73/kg by 2040. In addition to this, MACH2's extensive existing infrastructure, asset easements and ROWs, provide the highly cost-efficient interconnecting tissue of the Hub. Given MACH2's region and industrial presence, there will still be considerable captive industrial demand that will transition from incumbent fossil fuel-based sources of hydrogen to low carbon sources by 2040. Figure 8 shows a breakdown of the sectors with expected higher demand in 2040 and onwards for PA, NJ and DE combined.

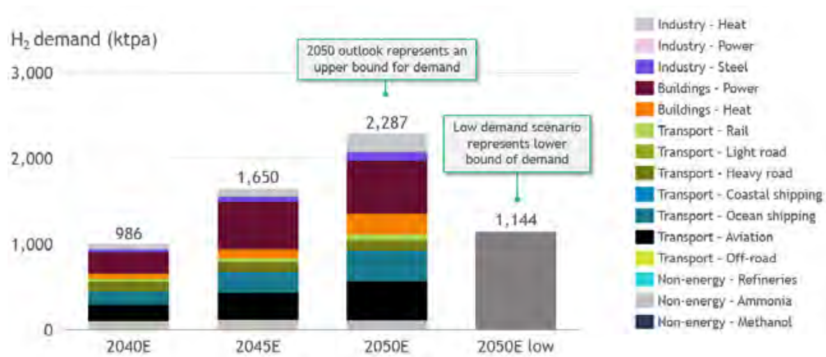

Figure 8: Projected 2040+ demand by sector for MACH2 hub

Projections show that longer term demand will largely be driven by the transportation sector, specifically heavy road transport, aviation, and shipping. Heavy duty road transport is expected to mature as improvements in fuel cell size & costs are realized. For example, the price for fuel cell vehicles, like buses, has already been reduced by 65% over the past 10 years[14]. A large part of MACH2's committed offtakers are in the transportation space, with Southeastern PA Transit Authority (SEPTA), City of Philadelphia, and DRS Tioga marine terminal actively pursuing a switch of their heavy-duty bus and trucking fleets to hydrogen fuel over the next 10 years. Other potential transportation offtakers, such as Delaware Area Rapid Transit (DART), have expressed interest in pursuing similar plans and may add to the Hub's future demand.

MACH2 is also uniquely positioned to play a large part in low carbon sustainable aviation fuels (SAFs). Monroe has a HEFA project through partnership with Delta Airlines where additional low carbon hydrogen is expected to be needed by the SAF process as it scales to meet airline demand. There has been additional interest by American Airlines and the Philadelphia airport to provide both potential demand and supply within the MACH2 hub. The HEFA, or animal fat and vegetable oil based SAF production processes (~30-58g CO_{2e}/MJ, respectively) have a carbon intensity ~40-70% lower than conventional jet fuel (~95 CO_{2e}/MJ) with potential to improve on this even further using low carbon hydrogen[15]. There are additional market tailwinds expected to help grow and differentiate the MACH2 hub further in this space, with major airlines announcing 10-30% SAF targets by 2030[16], translating to a ~70% market share from airlines with clear SAF usage commitment. The projected aviation H_2

[14] Ballard
[15] CARB, IRS
[16] Delta, Southwest, JetBlue, American Airlines, United, FedEx, UPS, DHL

demand by 2050 for the PA, DE and NJ within the hub is ~1240 mt/day by 2050. Even capturing ~5% of this regional demand is an additional ~60 mt/day, of which MACH2 should be well positioned to capture.

Lastly, MACH2 has ambitions to be a player in the low carbon shipping space, given the large demand for low carbon energy carriers, especially hydrogen for ammonia production. Ammonia is projected to meet 45% of demand for shipping fuel by 2050 in the Net zero scenario. Bioenergy and hydrogen are expected to meet a further 20% of demand, with the use of hydrogen mainly for short- to mid-range operations[17]. However, a significant gap in supply and demand for renewable ammonia (and methanol) for the maritime industry is expected by 2030, with demand of around ~30M tpa by 2030 and 183M tpa by 2050 but supply for existing, planned and announced green ammonia production by 2030 expected to be around ~5M tpa[18]. With access to many prominent ports in the region and a robust maritime industry, MACH2 can aid in not only the growth of hydrogen as a marine fuel but also in the growth of renewable ammonia production in the Mid-Atlantic. As identified through EPA's FLIGHT large emitters list, ammonia production operations in Hopewell, VA, could have a potential hydrogen demand of ~139 mt H_2/day[19]. MACH2 aims to establish relationships with ammonia producers to supply low carbon hydrogen in the future, as demand continues to grow regionally. In addition, MACH2 has had initial conversations with Amogy, a startup whose novel ammonia cracking technology produces power for transport applications, in marine and on-road. Their system has a 5x higher system-level energy densities compared to lithium batteries. They could be an additional demand partner, as ammonia and hydrogen production increases in the region. While realizing long-term demand potential will require overcoming challenges on commercial feasibility of future end uses, distribution, and investment, MACH2's partner's' conservative estimates and staggered ramp up plan provide confidence on demand growth potential. The team is in close collaboration with regional officials to encourage new clean energy investment to increase economic viability for all partners, helping to ensure their long-term sustainability.

Investments beyond award period: MACH2 is confident it will be able to attract follow on private investments beyond the award period due to attractive future at-gate hydrogen prices, expansion upon existing agreements and incumbent partners, and strong regional presence of additional potential off-takers. The abundance of existing infrastructure and needed feedstock resources reduces overall hydrogen delivery costs, gives MACH2 a clear scale-up advantage and an opportunity to further attract investments in new demand segments and hub regions (e.g., Midwest and Northeast alliances), as well as growing existing sector presence. MACH2 has already received plans from transportation end users for future demand at commercial scale. PSEG has potential plans to construct a hydrogen fueling station for heavy trucks and/or vessels at a shipping port within the hub and Delaware River Stevedores Inc, plan to also build and operate H_2 refueling stations for 93 vehicles. Port locations are an optimal central point for a fueling station for both heavy class 8 trucks and shipping vessels. Sunoco is currently involved in

[17] EIA 2022 World Energy Outlook
[18] IRENA: A Pathway to Decarbonize the Shipping Sector by 2050 (2021); ChemAnalyst; Note: conservative estimates with 2020 production volume as a proxy for existing capacity
[19] EPA FLIGHT; CO_2 emissions converted to hydrogen demand

discussions with MACH2 to provide access to their fuel stations and truck fleets that can be expanded for hydrogen transportation. As demand grows, Sunoco will be an important player for hydrogen transport within the hub. As part of MACH2, the City of Philadelphia (COP) also wants to build and operate H_2 refueling stations for 113 sanitation compactors and sweepers operated by Philadelphia Municipal Fleet at the 3901 North Delaware Ave area. A potential candidate for future hydrogen demand is the southern operating area of New Jersey Transit (NJT). NJT is developing their plans for carbon reduction, and they operate upwards of 400 buses in the area south of Interstate Rt.195. H_2 fuel cells are strongly considered in NJT's carbon solution for operational viability on long haul routes.

In the power space, Ameresco and PIDC have an interest in investigating the use f (and possibly production of) of hydrogen at the Philadelphia Navy Yard as part of PIDC's MicroGrid. In addition, MACH2 has had conversations with HyAxiom and DuPont Experimental Station, one of our committed demand offtakers, for a potential partnership to install a fuel cell microgrid on DuPont's extensive campus for power generation from MACH2's low carbon hydrogen supply. Braskem also has potential future plans to take low carbon hydrogen as they convert their fired equipment to use hydrogen vs natural gas at their Marcus Hook, PA facility.

National low carbon H_2 advancement: Given MACH2's carbon intensity is an average of less than -0.17 kg CO_{2e}/kg H_2 2024-2035, as detailed in the LCA section, and MACH2 is primarily pursing pink and green hydrogen, MACH2 is well positioned to be a leader in the USA's low carbon advancement. However, there is still room to reduce MACH2's emissions intensity further through efficiency increases in electrolyzer technology and renewable energy sources. As an initial step, PGW will be adding carbon capture to their orange hydrogen production project. Adding carbon capture to the RNG w/ SMR process reduces the carbon intensity even further from 0.2 kg CO_{2e}/kg H_2 to -6.5 kg CO_{2e}/kg H_2, as detailed in the DOE's GREET model.

Alongside looking to reduce MACH2's emissions intensity further, the Hub will look to pursue attractive and growing markets for low carbon hydrogen as the hub scales. Secured H_2 supply to the PHI airport and learnings from Monroe Energy's SAF processes with low carbon H_2 can foster advancements and future demand in air transportation. Bloom Energy's recent successful demonstrations for use of hydrogen in fuel cells for maritime transport and key partnership in the MACH2 hub will also be advantageous given MACH2's proximity to prominent ports and routes (e.g., Ports of Philadelphia, Southern NJ, and Wilmington). In addition, MACH2 is in conversations with Green H2, a hydrogen development company that is developing hydrogen production facilities in the Mid-Atlantic. Its first project is located at Kuehne Chemical in New Castle, DE where it will capture and upgrade 2mt/day of currently vented hydrogen. Green H2 is also developing additional projects using biogas from landfills and wastewater treatment facilities. By 2025 Green H2 expects to be producing a minimum of 10 tons/day of hydrogen in the region.

Given MACH2's partnerships with early-stage electrolysis partners such as Versogen, sHYp, and Hydropore, there is also a huge opportunity to invest and commercialize a diverse range of technologies. As mentioned earlier in the business plan, Versogen produces affordable anion exchange membranes using earth abundant materials. In addition, sHYp is a startup working with MACH2 to produce green hydrogen. sHYp specializes in seawater electrolysis using a membraneless electrolyzer that does not need high purity fresh water to operate and produces by-products like Mg $(OH)_2$ (Magnesium Hydroxide), an environmentally friendly co-product in comparison to the toxic brine sludge that is typically produced from desalination electrolysis. Mg $(OH)_2$ is also financially valuable and lowers the overall cost of green hydrogen produced from day one using this technology. Being able to utilize sHYp's technology at ports, given its potential location near or at the port of Wilmington or offshore to harness surplus electricity gives MACH2 a leading competitive edge to grow within the maritime industry. The City of Wilmington's Office of Economic Development is charged with bringing meaningful economic opportunities and jobs to the city. In the spirit of expanding its reach, the Economic Development Office has expressed interest in facilitating a green hydrogen project located in the vicinity of the Port of Wilmington, potentially on land owned/operated by the city, and especially on land that has no other beneficial use opportunities. The produced green hydrogen will be produced and used locally, potentially for large duty City vehicles, or for other uses.

Hydropore is also unique, given their technology is based off metal hydrolysis from nonprecious metals like zinc, magnesium, and aluminum. These metals react with water to produce hydrogen gas but are quickly inactivated, due to a water-resistant metal oxide that forms. Hydropore's technology creates sponge-like structures with zinc and aluminum, increasing their internal surface area, allowing all the metal to react and produce hydrogen before the metal oxide blocking layer can even form. The spent metal can be re-activated for reuse, reducing costs and environmental impact. Given how quickly the reaction can proceed, it gives huge flexibility for hydrogen to be produced on demand for a variety of use cases.

Management Plan

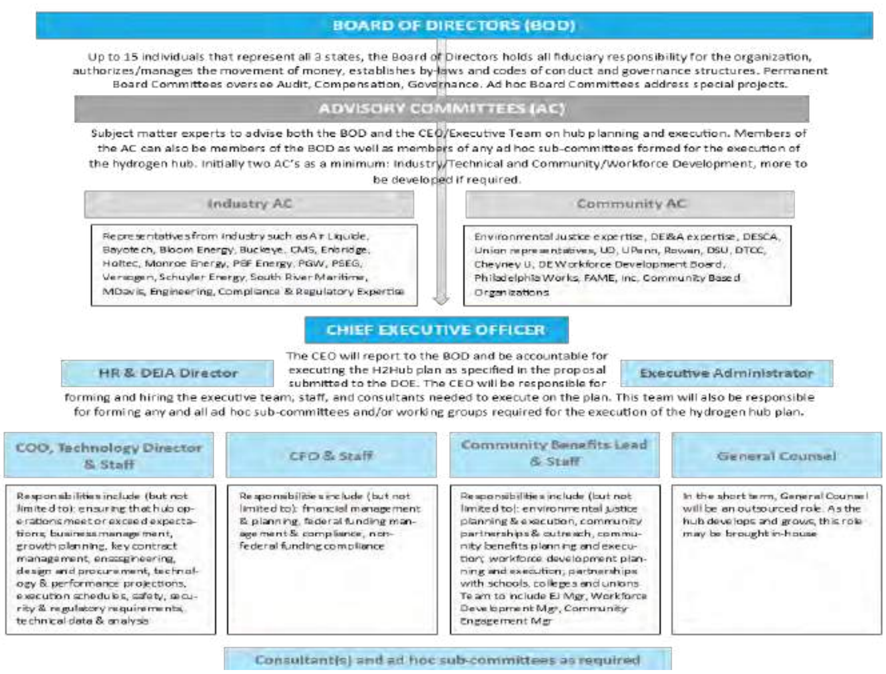

Figure 9: MACH2 Organizational Chart

Board of Directors: MACH2 will be led by a Board of Directors (BOD) which will include government representatives from all 3 regions (Delaware, Pennsylvania, New Jersey) as well as representatives from industry, academia and labor. The MACH2 BOD holds all fiduciary responsibility for the organization and authorizes/manages the movement of money between the organization and partners. The BOD will be responsible for establishing corporate by-laws, codes of conduct, governance structures and for employment of the Chief Executive Officer. Permanent Board Committees will be formed to lead/oversee Audit, Compensation and Governance/Nominating. Ad hoc Board Committees will address special projects and issues.

Executive Team: The Chief Executive Officer (CEO) and the Executive Team will report directly to the BOD and be accountable for executing the hub plan and meeting milestones, budgets and strategic goals as set forth in the plan. The CEO will be responsible for forming and hiring the executive team staff, and consultants needed to execute the plan. This will include the Chief Operating Officer and technical staff, Chief Financial Officer and staff, Community Benefits Director and staff, Human Resources & DEIA Director, Executive Administrator, General Counsel. The above team will be responsible for forming any and all ad hoc sub-committees and working groups required for the execution of the hub, and ensuring regular communication with the DOE, project partners and community stakeholders on hub development.

Advisory Committees: Advisory Committees (AC) will be formed consisting of subject matter experts to advise the BOD and the Executive Team on specific areas of hub development. These non-voting/non-executive roles will advise and support. Two ACs will be formed initially with more added if deemed necessary by the BOD or the Executive Team.

Industry AC: Consisting of technology, engineering, compliance & regulatory experts, members will be drawn from regional partners and stakeholders such as Air Liquide, Bloom Energy, Compact Membrane Systems, Enbridge, Holtec, Monroe Energy, PBF Energy, PGW, PSEG, Versogen, Schuyler Energy, South River Maritime, MDavis.

Community AC: Consisting of environmental justice, workforce development, DEIA experts, and drawing on community outreach and convening expertise, members will include regional partners/stakeholders including Union representatives (steamfitters, pipefitters, building trades), Philadelphia Works, DE Workforce Development Board, University of Delaware, University of Pennsylvania, Rowan University, Cheyney University, Delaware State University, Delaware Technology & Community College, Philadelphia Works, FAME, Inc DESCA, Community Based Organizations.

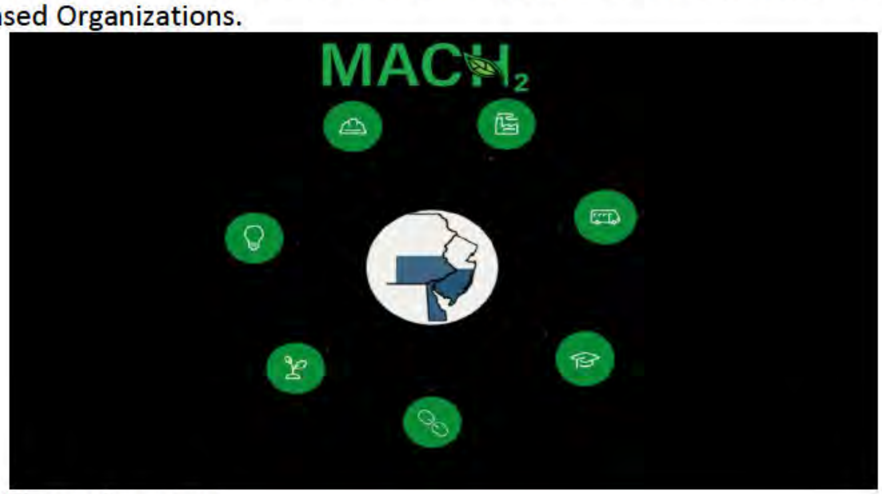

Figure 10: MACH2 Partner Ecosystem

While not all stakeholders will be sub-recipients of DOE funds, most if not all will play a role, directly or indirectly, as the hub develops and grows. The prime applicant and recipient of DOE funds will be the Mid Atlantic Hydrogen Hub Inc (MACH2). The MACH2 Board of Directors holds all fiduciary responsibility and authorizes and manages the movement of money between the organization and the partners. The relationship between MACH2 and all project partners will be contractual, encompassing (but not limited to) project schedules, milestones, budgets, timelines, and reporting. For project partners represented on the Board of Directors, conflict of interest clauses will be included. All project partners will be responsible for ensuring that their supply chain partners are able to meet/exceed the schedules, milestones, budgets and other requirements as set out in the contract between MACH2 and the project partner. The Mid Atlantic Hydrogen Hub (MACH2) has been established as a 501(c)(3) non-profit entity specifically for the purpose of developing a regional clean hydrogen hub that will connect hydrogen producers and consumers via connected infrastructure located within the Mid-Atlantic Region of the US. This region encompasses the entire state of Delaware, Southern New Jersey and Southeastern Pennsylvania, making it an engine for growth and opportunities in clean hydrogen production, transportation and consumption, increasing employment opportunities and enhancing the economic welfare of the region.

Table 2: MACH2 Project Partners

Organization + Role	Project Partner Details
Chesapeake Utilities **Production**: 7 mtpd renewable electrolysis **Distribution:** fueling and truck distribution	Chesapeake Utilities is a diversified utility company engaged in natural gas distribution, transmission, and marketing; electric distribution; propane gas distribution and wholesale marketing; advanced information services and other related services.
City of Philadelphia **Consumption**: 6 mtpd through fleet conversion	The City of Philadelphia has committed to converting to consuming approx. 6 mtpd hydrogen by converting vehicles among the municipal fleet.
Delaware River Stevedores (DRS) **Consumption:** 3 mtpd for drayage trucks	DRS is a full-service cargo handler, stevedore, and marine terminal operator. DRS operates the Tioga Terminal in the Port of Philadelphia and provides cargo handling and stevedoring services at the South Jersey Port Corporation's Balzano and Broadway Terminals in the Port of Camden, and at the Diamond State Port Corporation Terminal in Wilmington, DE.
DuPont Experimental Station **Consumption**: 2 mtpd power generation confirmed. >50 mtpd if converted to microgrid (TBD)	The DuPont Experimental Station is a 40+ building campus in Wilmington Delaware that is seeking to incorporate hydrogen as a power generator to decarbonize day-to-day operations. DuPont today is a highly diverse conglomerate with interests in chemicals, agriculture, electronics, and packaging.
Enbridge **Consumption:** 16 mtpd renewable electrolysis **Storage/Distribution:** Retrofit of existing crude oil pipelines (45 mtpd)	Enbridge operates across North America and Enbridge assets move 30% of the crude oil produced in North America, transporting nearly 20% of the natural gas consumed in the U.S. Enbridge is North America's largest natural gas utility by volume. It also operates Canada's largest natural gas utility and has two decades of experience as an investor and developer in renewable energy projects, including a growing offshore wind portfolio.

Hilco Redevelopment Partners (HRP) **Consumption:** 251 mtpd power and steam generation	HRP is a vertically integrated real estate investment and redevelopment company that remediates and redevelops obsolete industrial sites across the United States. HRP's approach prioritizes economic, community and environmental sustainability, transforming properties and the communities surrounding them through a comprehensive approach to community engagement, environmental sustainability, and economic development.
Holtec Government Services **Production:** 28.5tpd renewable electrolysis	Holtec International is a diversified energy technology company with its headquarters located in Jupiter. The company is widely recognized as the foremost technology innovator in the field of carbon-free power generation, specifically commercial nuclear and solar energy.
Messer **Production:** 28 mtpd renewable electrolysis	Messer is a leading industrial and medical gas company serving North and South America, delivering quality gases through an extensive distribution network. Messer has over 70 production facilities and approximately 5,000 employees and operates in the US, Canada, Brazil, Colombia, Chile and Puerto Rico.
Monroe Energy **Consumption:** 50 mtpd confirmed for boilers (combustion), potential additional demand of 50 mtpd for sustainable airline fuels	In 2012, Delta Airlines formed Monroe Energy and its affiliated company, MIPC, LLC, to purchase a 185,000-barrel-per-day oil refinery and its associated pipeline assets, in Trainer PA near Marcus Hook. This strategic location in southeast Pennsylvania provides access to a network of pipelines, proximity to assets throughout the NE and an experienced and skilled labor pool. Monroe Energy intends to cease production of traditional ground petroleum fuels and become a manufacturer of sustainable aviation fuel.
PBF Energy **Production**: 76 mtpd **Distribution:** Truck transportation with future pipeline build out	PBF Energy owns 2,500 of underutilized land in New Castle County, DE that is available to fast-track development of a H2 production facility (~76 mtpd). The site provides direct access to the interstate highway system via the I-95 corridor, and nearby railroads, ports and airports provide additional transportation options as well as potential consumers. PBF owns pipeline RoW between the site and Twin Oaks, PA, that will be leveraged for a pipeline connection into the IRPL (Inter refinery pipeline)
Phila. Gas Works **Production:** 14.9 mtpd renewable electrolysis and 7.5mtpd orange SMR with RNG (orange H2) and CCUS **Distribution:** 12.1 tpd through new pipeline	Philadelphia Gas Works employs 1,600 workers and distributes natural gas to approx. 522,000 customers through 6,000 mi of gas pipelines across the city. PGW is seeking to develop two existing properties for H2 production initially using the more mature and cost competitive SMR process with renewable natural gas and carbon capture.
PSEG **Production:** 25 mtpd nuclear electrolysis	PSEG **i**s a publicly traded diversified energy company headquartered in New Jersey, and one of the ten largest electric companies in the U.S. Employing more than 12,000 workers, PSEG total assets (2022) equaled $48.8 billion with annual revenues of $9.8 billion. Between 2017 and 2020, PSEG Power LLC completed the development and construction of three new gas fired combined cycle units.
sHyP LLV	sHYp BV PBC is a green hydrogen company focused on seawater for hydrogen production from electrolysis. sHYp's innovations are two-fold: a

Production: 4 mtpd renewable electrolysis	membrane-free electrolyzer design enables durable operation in seawater environments and a systems design enables direct use of seawater as the water source without the need for desalination or water purification.
Southeastern PA Transit Authority (SEPTA) **Consumption:** 24 mtpd for fleet conversion	SEPTA's primary demand for H2 would come from the conversion of the existing hybrid-diesel bus fleet to a hydrogen fuel cell electric bus fleet. SEPTA anticipate converting 1400 diesel buses to H2FC over the performance period.
Versogen **Production:** 124 mtpd renewable electrolysis	Versogen is prototyping a state-of-the- art anion exchange membrane-based electrolyzer (AEMEL) using earth abundant materials and that reduces the cost of green H_2 compared to other production technologies. With MACH2, Versogen can greatly accelerate the development of AEMEL and deployment of green H_2 to industry in the Mid-Atlantic region.

Other project partners that have submitted projects but not requested DOE funding include:

Organization + Role	Project Partner Details
Air Liquide **Consumption, Distribution, Storage and Supply Chain**	Air Liquide is a pioneer in the hydrogen market with over 60 years of experience across the hydrogen value chain from production, distribution and storage to the development of end-use applications. Through its partnership with MACH2, Air Liquide intends to act as a future offtaker of renewable gaseous hydrogen produced by MACH2 funding recipients. This will translate into evaluating an investment in the liquefaction of 30 tpd of gaseous hydrogen, and corresponding distribution assets to serve the growing demand from the mobility market, especially the heavy-duty segment and aviation. Air Liquide's potential investment - if economically viable - would be estimated to be upwards of $300 million.
Bloom Energy **Supply chain:** Electrolyzer manufacturing	Though not a primary sub-recipient, Bloom Energy's electrolyzer technology will be deployed in sub-recipient projects. Bloom Energy has East and West Coast facilities and are in the process of building out electrolyzer manufacturing capabilities in DE with more than 40% growth in clean energy jobs projected. Bloom has an existing 27 MW fuel cell farm in DE that could be upgraded from natural gas to H_2 for electricity production.
Braskem **Consumption:** Potentially 5.5 mtpd	Braskem is the largest petrochemical company in the Americas and the world's leading biopolymer manufacturer, producing polyethylene (PE), polypropylene (PP) and polyvinyl chloride (PVC) resins, as well as basic petrochemicals. In 2022, Braskem realized gross revenues of $16 billion, net revenue of US $14 billion, EBITDA of $2.8 billion and investments of $714 million
Croda **Consumption:** Confirmed 2 mtpd	Croda develops and manufactures high-performance ingredients and technologies featured in many popular consumer brands as well as health and crop care products. The company manufactures 100% bio-based surfactants, the first of their kind in the U.S., which are found in soaps, makeup, etc. CRODA's facility at Atlas Point boasts 100% renewable electricity, which support Croda's 1.5°C science-based target and its wider sustainability Commitment to become Climate Positive.
Delaware Area Rapid Transit (DART) **Consumption**: Potentially 12 mtpd	DART plans to convert 173 buses and 50 support vehicles from diesel to H2 fuel cells by 2040. DART serves highly dense cities with significant low-income populations and are committed to reducing air pollution within their communities.

**None of the hub major partners is foreign owned.*

Management**:** The MACH2 Executive Team will employ as a minimum traditional organizational and operational strategies and methodologies not only to ensure that partners, sub-recipients and vendors meet contractual goals, but also to ensure progress and risks transparency throughout the program through active governance and program management, as well as to streamline and standardize processes wherever possible, to accelerate hub development. Consultants, subcontractors and subject matter experts will be employed wherever applicable to accelerate and/or lead on strategies and tactics. Such strategies include:

Site Selection: Site decision methodologies that ensure ample production, storage and distribution space with additional room for potential growth, permitting and safety while also addressing environmental justice and workforce development needs.

Hub Capacity & Design: Project design mapping that outlines every step in the production phase of each of the projects as they relate to the overall hub. Within the budget we include the tools, technologies, systems, consulting support, and any relevant continuous education for project managers necessary to ensure a robust project management system that includes:

- Project objective, basic assumptions, scope of work, and financial analysis
- Technical feasibility, constructability, and sustainability
- Project implementation resource availability
- Verification of incentives – the risk of "sunset" before commissioning. Are all possible incentives accounted for, such as utility, municipal, state, and federal?
- Clarification of expectations, goals, schedule milestones
- Funding request and approval process
- Project mapping and Project team formation
- Phased implementation of the projects
- Identification/implementation of applicable safety measures during each phase
- Holistic program management with active governance, interdependencies, risks and KPIs tracking
- Identification of regulatory requirements during each phase of the project
- Protocols for communications between all concerned employees, staff, supervision, members of the management associated with the project and the DOE
- Required training of installation crew and necessary communications to all concerned
- Start-up, testing, and commissioning
- Verification of projected output or energy savings

Hub Sustainability

Economic: MACH2 leadership will employ strategies and methodologies that ensure the hub can achieve long term profitability, create risk management plans, ensure adherence to compliance policies, and ensure that all stakeholders are satisfied with hub operations. The economic sustainability strategy will also incorporate as a minimum plan to ensure long term, cost-effective feedstock supply and offtake agreements and strategies to capture hard-to-carbonize industries (cement, steel manufacturing, glass manufacturing, aviation, maritime and long-distance trucking) that offer growth potential.

Environmental: MACH2 leadership will implement methodologies to capture/measure the hub's carbon footprint and assess how daily operations affect the environment, including

Life Cycle Analysis using the GREET Greenhouse Gases, Regulated Emissions and Energy Use in Transportation) model.

Social: MACH2 leadership will implement outreach strategies to ensure positive perception of hub by employees, stakeholders, community members and potential consumers. This includes execution of the Community Benefits Plan; bridging communication gaps between internal and external stakeholders and ensuring everyone (MACH2 Hub employees, DOE, partners, consultants, advisory committees, ad hoc sub-committees and board of directors) are on the same page regarding hub goals and objectives; audience-specific communications that close education/knowledge gaps in traditionally underserved communities and underscore EJ, workforce development and DEI&A opportunities and barriers.

Finance & Compliance: MACH2 will develop a finance-organization design structure and methodology that is lean and effective and can provide timely and accurate data for financial forecasting, planning and analysis with an emphasis on risk management and mitigation; federal funding management and compliance, and investor/stakeholder communications and relations.

Community Benefits: The Community Benefits Team and HR & DEIA Director will serve as intermediaries between communities, organizations, and industries that struggle to communicate and collaborate. By holding trusted relationships across boundaries, beginning with an internal culture of DEIA and extending outwards, they will help to facilitate connection, translate interests and intentions, curate and communicate essential knowledge, and identify points of shared interest for collaboration. On a project with the complexity, breadth of interests, and impact on stakeholders that MACH2 will have, there are a set of internal capacities that are essential to ensuring its success across project phases, particularly regarding the Community Benefits Plan. The MACH2 team must possess the capacity for very specific types of leadership:

- Relational leadership**,** where staff of MACH2 are trusted partners who are skilled at brokering connections and collaboration across the specific boundaries at play
- Facilitative leadership, where MACH2 acts as the convener of conversations and participatory processes requiring, expertise in creating contexts for collaboration through process design and facilitation,
- Knowledge leadership, where MACH2 generates relevant and useful knowledge to pressing questions, requiring research expertise in Participatory Action Research or similar transdisciplinary research methods,
- Cultural leadership**,** where MACH2 models "a way of operating" through in house expertise at crafting collaborative organizational practice.
- Administrative leadership, where MACH2 makes everyone's work easier through "keeping the trains running".

MACH2 was formed in January 2023 specifically for the purpose of developing a regional clean hydrogen hub. The organization has been led by an Interim Leadership Team until such time as funding is received to fully execute on hub development. Once funding has been received the Board of Directors will immediately embark on employing a CEO who will in turn hire their team to execute the plan. The Interim Leadership Time has the qualifications, experience, capabilities and stakeholder relationships necessary to build the framework, strategic vision and roadmap for a hydrogen hub. This team also has the organizational knowledge necessary to build out a fully functional entity and staff that can execute on the hub plan. The interim team includes:

Table 3: MACH2 Interim Leadership Team

CEO: Martin R. Wade III	Wade has nearly 40 years' experience advising senior management and Boards of Directors on more than 200 strategy, acquisition, divesting and restructuring projects and has served on 22 corporate boards as well as a private equity firm and is currently Board Co-Chair of Giga Carbon Neutrality.
CTO: Joseph Colella	Colella, Founder of Schuyler Energy has held executive level positions at Buckeye, Energy Transfer, and Sunoco Logistics for the past 20+ years, during which time he developed advanced expertise around product pipelines and terminals.
Technical Lead: George C. Murphy	Murphy, Founder of South River Maritime, has had a 45-year career in all aspects of waterborne supply and distribution, starting as a seagoing marine engineer and culminating in holding the highest marine operations position at Sunoco, affording him the expertise to continue as a comprehensive marine consultancy.
Board Chair: Collin O'Mara	O'Mara is the CEO of the National Wildlife Federation, America's largest conservation organization with deep expertise in hydrogen and climate solutions, which helped develop and pass the Energy Act of 2020, the Infrastructure Investment and Jobs Act, and the Inflation Reduction Act.
Board Vice Chair: Jim Snell	Snell is the Business Manager for Steamfitters Local Union 420. His relationships with labor unions, experience in fostering and promoting employment for union members, including the authoring of Collective Bargaining Agreements plays a crucial role in our hub which will focus heavily on union labor.
Board Secretary: Dora Cheatham	Cheatham is the Executive Director of DESCA, a non-profit organization that plays a key role in convening leaders in the public and private sectors on emerging issues and opportunities in the chemical industries, as well as driving innovation and collaborative partnerships between major strategics, startups and universities to commercialize new technologies and build a talent pipeline.
Manny Citron	Citron is the Chief of Staff for the Philadelphia Department of Labor and brings with him over a decade of experience in labor policy and compliance, legislation and policy recommendations, operations, community outreach and leading cross-functional teams on mission-critical projects.
Michael J. Maitland	Maitland is a public service profession with over 15 years' experience in all levels of American government achieving policy goals, building coalitions, developing networks and leading diverse teams. He is also a skilled executive with expertise in managing transformational change, achieving strategic goals, and empowering and motivating teams and individuals.
Dr. Yushan Yan	Yan is the Henry B. DuPont Chair in Chemical and Biomolecular Engineering at the University of Delaware with over 300 publications and 25 issued patents. He has also participated in the launch of multiple startups in the chemical and clean energy industry. In 2022, he launched the Center for Clean Hydrogen at the University of Delaware in partnership with Chemours, Plug Power and the National Renewable Laboratory, and is the Center's Founding Director.

Once funding has been received the Board of Directors will immediately embark on employing a CEO who will in turn hire/outsource the team and experts required to execute the plan. The Leadership Team to be recruited post award will include:

Table 4: MACH2 Post-Award Leadership Team

Position	Responsibilities	% Time
CEO – Martin R. Wade III	Accountable for execution of hub plan, Forming and hiring of MACH2 executive team and staff, Business development & growth planning – including formulating strategies to capture hard-to-decarbonize industries, Hub sustainability	100%
COO – to be named	Hub development and operations including engineering, design and procurement; technology & performance projections; execution schedules, safety, security & regulatory requirements, technical data & analysis, key contract management, including cost-effective feedstock supply and offtake agreements business management & growth planning, Stakeholder communications	100%
CFO – to be named	Financial management & planning, Federal funding management & compliance, Non-federal funding compliance	100%
HR & DEIA Director	Develop internal HR policies as well as internal and external DEIA policies that extend across all areas of the hub. Work closely with the Community Benefits Team to ensure DEIA is encompassed throughout all hub activities.	
Community Benefits Lead	Environmental justice & community benefits planning & execution to include community partnerships and outreach, relational leadership, knowledge leadership, cultural leadership, facilitative leadership and administrative leadership. Workforce development planning and execution to include partnerships with schools, colleges and unions to develop workforce training & retraining programs, internships, apprenticeships. Drive and embed organizational level DEIA policies and initiatives throughout all EJ, workforce development and community outreach initiatives and activities	100%
General Counsel	In the short term (Phase 1), General Counsel will be an outsourced role. As the hub develops and grows (Phase II and beyond), this role will be brought in-house.	Outsourced

Experience

MACH2 has partnered with established leaders, as well as growing innovative startups and technologies, for the overall vision, structure, and cohesion of its Hub. These partners have long and extensive experience in energy technologies and infrastructure, as well as large capex project deployment and execution, including stakeholder outreach and engagement. The following are examples of current and past projects undertaken by MACH2 Project Partners.

Energy Infrastructure Project Examples

Chesapeake Utilities is a diversified utility company engaged in natural gas distribution, transmission, and marketing; electric distribution; propane gas distribution and wholesale marketing; advanced information services and other related services. With about 1,500 miles of natural gas distribution mains, CPK distributes natural gas to approximately 100,000 residential, commercial, and industrial customers across Delaware and Maryland. The company has $1.9 billion in assets and has made capital investments of $195.5 million in 2020 and more than $1.0 billion over the last 5 years. Among Chesapeake's major projects:

- <u>DelMar Energy Pathway</u> – a $45M project to increase gas transmission capacity to lower Delaware and Maryland. The project began in January 2020 and was completed in September 2021, placing 5 facilities into service that deliver an aggregate of 14,300 dt/d of additional gas and bringing natural gas to Somerset County, MD (one of only 3 counties in the state whose end-users did not have access affordable natural gas).

- Callahan Interstate Pipeline – a $34M project to supply gas to Florida's Nassau and Duval counties. The project was started in 2019 and completed in October 2020. The project – a 26-mile pipeline – brought additional natural gas capacity to Florida's Nassau and Duval Counties to meet the growing demand for natural gas in the area.

PBF Energy Inc. is one of the largest independent refiners in North America, operating through its subsidiaries, oil refineries and related facilities. In California, Delaware, Louisiana, New Jersey, and Ohio. PBF's total crude oil throughput capacity is approximately 900,000 barrels per day, making it the fourth largest independent refiner in North America. PBF has developed numerous large capex projects including process units at refineries, pipelines, and other infrastructure projects. Their most recent project to come online in 3Q2023 is a 50-50 joint venture with the Italian energy company ENI called, St. Bernard Renewables LLC (SBR). It is a biorefinery co-located with PBF's Chalmette Refinery in Louisiana. The project is estimated to cost approximately $1 billion and ENI Sustainable Mobility will contribute capital totaling $885 million. The facility is currently targeted to have a processing capacity of about 1.1 million tons/year of raw materials, with a production capacity of 306 million gallons per year.

Energy Infrastructure Operations & Maintenance Examples

Enbridge operates across North America and Enbridge assets move 30% of the crude oil produced in North America, transporting nearly 20% of the natural gas consumed in the U.S. Enbridge is North America's largest natural gas utility by volume. It also operates Canada's largest natural gas utility and has two decades of experience as an investor and developer in renewable energy projects, including a growing offshore wind portfolio. Together, its renewable energy projects (either operating or under construction) have the capacity to generate nearly 2,000-megawatt (MW) net of zero-emission energy. Enbridge has completed numerous projects more than $1 billion CAPEX and that took more than two years to plan, engineer and construct including the following two projects:

- Valley Crossing Pipeline – started in 2019, this currently operating pipeline is 168-mile gas line from Agua Dolce, TX to Brownsville, TX with a daily capacity of over 2.5 billion cubic feet. In January 2020, Enbridge agreed to expand the pipeline a further 10 miles beginning in 2026.
- Sabal Trail Pipeline – started in 2017, the Sabal Trail is a $3.12 billion, 515-mile natural gas pipeline from Georgia to Florida. Sabal Trail brings additional affordable natural gas supplies to Florida, while increasing the reliability of the region's energy delivery system.

Energy Infrastructure Projects and Disadvantaged Communities

Holtec International is a diversified energy technology company widely recognized as the foremost technology innovator in the field of carbon-free power generation, specifically commercial nuclear and solar energy. The company operates globally with offices in more than 10 countries where they have constructed multiple major projects for the storage and handling of nuclear materials and heat transfer systems including air-cooled condenser technology. An example of Holtec project development capability is their 50-acre state-of-the art $260 million *Krishna P. Singh Technology Campus* on the Delaware River in the economically depressed city of Camden, NJ. This project has helped revitalize Camden, a former bastion of technology and manufacturing excellence, after five decades of decline. The Camden Campus houses a technology center, a large manufacturing facility and a reactor test loop and several as well as auxiliary buildings to support the ongoing development of Holtec's small modular reactor, SMR-160. The company expects to train and employ over a thousand workers from the Camden area, including war veterans, in the first two years of operation to rejuvenate the manufacturing base in the South Jersey region. In addition, Holtec boasts an unblemished record of performance (no client litigation, no long-term debt, no unprofitable fiscal year, and no client call on any posted bond, etc.) that has enabled the banks and insurance companies to view Holtec as a zero-risk borrower. Holtec governance is exceptional, and their supply chain specialist maintain a confidential "excluded entities list" (EEL) consisting of those suppliers that have been determined to be incompatible with Holtec's corporate values (such as anyone indicted for corruption, document falsification, etc.).

PSEG Projects encompass several levels of Community Engagement. Corporate Citizenship is a component of each project and of continued operations.

Community Engagement: Using the examples of their McCarter Switch Project in Newark and the Bridgeport Harbor Station Unit 5 Combine Cycle Project, PSEG gathers input from the state, counties, municipalities and neighbors when designing, constructing on and operating our assets. These inputs include but are not limited to: Workforce development engagement and hiring, esthetic design of infrastructure, hosting and attending listening/information sessions, supporting procurement and jobs fairs in partnership with local apprenticeship training institutions and labor unions, and providing the public with consistent and reliable project updates and communications via social media, websites, and telephone.

Workforce Development: PSEG has a successful track record in supporting the career development of careers in the building and construction trades through community benefit agreements such as their Ready2Work Program. In conjunction with the construction of a capital project in Connecticut, PSEG invested $700,000 in workforce development to manage, support, and house on site a state-certified pre-apprenticeship program consisting of five classes over 14 months and resulting in a73% placement rate in the local building trades unions. The program was created in partnership with a local American Job Center, the State of Connecticut Workforce Development Board, the Fairfield County Building and Construction Trades Unions and the only pre-apprenticeship program in the state. PSEG is also an integral partner of the county college system in the State of New Jersey. The corporation supports STEM initiatives and workforce training at many locations. For example, in Salem County PSEG supports and partners with Salem County Community College's Nuclear Energy Technology associate in applied science Degree to ensure a local pipeline of qualified employees.

Pending Investigations

There are no pending or threatened actions, suits, proceedings, investigations, including action or proceeding before any governmental authority, that relate to the Hub's interim team introduced previously in this section.

Financial Plan

Prime Applicant and Project Partners

Table 5: MACH2 Partner Contact Information

Organization / Entity	Hub Ownership	Website	Address	City, State	ZIP Code
Chesapeake Utilities	None	www.chpkgas.com	500 Energy Ln	Dover	DE 19901
City of Philadelphia	None	https://www.phila.gov/	City Hall	Philadelphia	PA 19107
Delaware River Stevedores	None	http://d-r-s.com/	441 N 5th St, Ste 210	Philadelphia	PA 19123
DuPont Experimental Station	None	www.dupont.com	200 Powder Mill Rd	Wilmington	DE 19803
Enbridge	None	www.enbridge.com	Ste 1100, 915 N Eldridge Pkwy	Houston	TX 77079
Hilco	None	www.hilcoglobal.com	2929 Arch St, Ste 1650	Philadelphia	PA 19104
Holtec	None	www.holtecinternational.com	1001 N US Hwy 1	Jupiter	FL 33477
Messer (US)	None	www.messer-us.com	200 Somerset Corp Blvd Ste 7000	Bridgewater	NJ 08807
Monroe Energy	None	www.monroe-energy.com	4101 Post Rd	Marcus Hook	PA 19061
PBF Energy	None	www.pbfenergy.com	403 Hamburg Corner River Rd	New Castle	DE 19720
PGW	None	www.pgworks.com	800 W Montgomery Ave	Philadelphia	PA 19122
PSEG	None	https://corporate.pseg.com/	80 Park Place	Newark	NJ 07102
SEPTA	None	https://iseptaphilly.com/	1234 Market St	Philadelphia	PA 19107
sHYp LLV	None	https://shypbv.com/	200 Powder Mill Rd, E500/2803	Wilmington	DE 19806
Versogen	None	www.versogen.com	1090 Elkton Road – S115	Newark	DE 19711

Financial Strength

While more information on our partners can be found in the partners experience section, overall, MACH2's partners are mature companies with a history of successful execution of large capital projects and strong financial performance across a number of dimensions. For publicly traded partners, the MACH2 team has assessed their financial situation based on partners 10-K reports. As illustrated on Table 6, all partners with publicly available information present strong performance across a number of dimensions. PBF Energy, PSEG, Enbridge Energy and DuPont all present overall positive EBITDA and Earnings trajectories during the last 5 years. All companies except PBF Energy present ROEs above 7-8%. PBF's Energy Return on Equity in 2020 is due to the impact of the pandemic on refining operations. Although not reflected on the table, during 2022, as refining margins rebounded and spiked due to the Russia Ukraine war, PBF managed to capture these margins and lower net debt by $3.2Bn, being from over levered to a net cash position in a single year.

Table 6: Select financial data for MACH2 publicly traded partners.

	2016	2017	2018	2019	2020	2021
PBF Energy (PBF)						
EBITDA ($M)	134	593	894	569	(1,229)	228
Earnings from continuing operations	226	483	175	375	(1,333)	316
Debt / Enterprise Value Ratio (%)	43%	36%	33%	40%	102%	85%
Return on Equity Ratio (%)	-7%	5%	14%	4%	-104%	-13%
Current Ratio[20]	1.66	1.57	1.52	1.52	1.58	1.38
Credit Rating						
Fitch Ratings	BB-	As on December 09, 2022				
S&P Global Ratings	BB	As on November 21, 2022				
PSEG (PEG)						
EBITDA ($M)	3,370	2,688	3,722	3,964	3,865	3,525
Earnings from continuing operations	887	1,574	1,438	1,693	1,905	(648)
Debt / Enterprise Value Ratio (%)	34%	34%	36%	35%	36%	37%
Return on Equity Ratio (%)	10%	11%	11%	12%	10%	9%
Current ratio	0.99	0.79	0.71	0.64	0.66	0.88
Credit Rating						
Fitch Ratings	-	N/a				
S&P Global Ratings	BBB	As on March 03, 2023				
Enbridge Energy Partners (ENB)						
EBITDA ($M)	4,726	7,314	7,935	9,200	8,818	9,430
Earnings from continuing operations	3,032	4,874	5,438	6,638	6,048	6,357
Debt / Enterprise Value Ratio (%)	40%	39%	40%	36%	42%	41%
Return on Equity Ratio (%)	16%	12%	7%	10%	9%	11%
Current ratio	0.65	0.63	0.58	0.55	0.53	0.49
Credit Rating						
Fitch Ratings	BBB+	As on August 22, 2022				
S&P Global Ratings	BBB+	As on October 4, 2022				
Chesapeake Utilities Corporation (CPK)						
EBITDA ($M)	123	130	144	158	180	203
Earnings from continuing operations	45	58	57	61	71	83
Debt / Enterprise Value Ratio (%)	24%	26%	32%	32%	27%	23%
Return on Equity Ratio (%)	10%	12%	12%	10%	9%	10%
Current ratio	0.42	0.43	0.36	0.32	0.42	0.46
Credit Rating						
Fitch Ratings	BB+	As on July 20, 2022				
S&P Global Ratings	-	N/a				
DuPont (DD)						
EBITDA ($M)	8,694	11,218	16,905	5,181	4,787	4,099
Earnings from continuing operations	4,404	1,669	4,004	(614)	(2,874)	1,804
Debt / Enterprise Value Ratio (%)	23%	17%	25%	27%	30%	22%
Return on Equity Ratio (%)	24%	5%	8%	4%	0%	7%
Current ratio	1.9	1.9	2.0	1.2	2.3	1.9
Credit Rating						
Fitch Ratings	BBB+	As on March 15, 2023				
S&P Global Ratings	BBB+	As on March 28, 2020				

For project partners not described in detail on the experience section please refer to table 3 above for a description of who they are and what they do.

[20] Current Assets divided by Current Liabilities

Lastly, given how MACH2 is primarily a green and pink hub, the emissions associated with the production of the hub's hydrogen are well below the emissions associated from incumbent fossil fuel methods of production. MACH2's expected weighted average LCA well-to-gate carbon intensity is -0.14 kg CO_2e/kg H_2in line with GREET model assumptions. Thus, MACH2 can aid in advancing the sustainability goals of the hub's key players, of which the majority are actively monitoring and looking for ways to reduce their overall emissions footprint. Some example key player's sustainability goals include PSEG's net-zero climate vision for 2030: Carbon-free electricity generation, transition to net-zero operations (scope 1 and 2 emissions) and enabling an economy-wide decarbonization, and Enbridge's ambition is net zero greenhouse gas (GHG) emissions by 2050; with an interim target to reduce GHG emissions intensity 35% by 2030.

Other Federal Support & Non-Federal Support

There are multiple additional award programs through the US Department of Transportation and the US Department of Energy that support growth, research, and consumption in clean hydrogen space. The US Department of Transportation offers 1) the Charging and Fueling Infrastructure Grants program, which support electric and hydrogen powered vehicle fueling infrastructure access on a community and commercial corridor level, 2) the Buses and Bus Facilities program, which assists in the financing of replacing, rehabilitating, purchasing, or leasing buses, and 3) the Low or No Emission Vehicle program, which supports the purchase or lease of zero-emission and low-emission transit buses, including acquisition, constructure, and leasing of required supporting facilities.

The US Department of Energy offers 1) the Clean Hydrogen Electrolysis, Manufacturing, and Recycling program, which supports the development of manufacturing and recycling of clean hydrogen technologies and electrolyzer development, 2) the Support of the Hydrogen Shot and University Research Consortium on Grid Resilience program, which will support the research and development of affordable hydrogen and fuel cell technologies, and 3) the Regional Clean Hydrogen Analysis program, which will support analysis projects to identify and characterize the value proposition of specific regional clean hydrogen deployments.

As stated in the Business Development and Management section, the MACH2 region itself has a favorable legislative and policy environment for clean energy, with PA, NJ, and DE pushing to reshape their economy to a lower carbon one by 2050 through their respective climate action plans. In addition to the generous federal incentives set forth in the Inflation Reduction Act and the Infrastructure Investment and Jobs Act for hydrogen production, there are state incentives that the hub can access for additional investment and expansion. PA and NJ also offer zero emission vehicle incentives.

<u>PA State Grants</u>

- Department of Community and Economic Development grants include: 1. Alternative and Clean Energy Program, 2. Industrial Sites Reuse Program, 3. Local Share Account, 4. Manufacturing PA industrial Resource Center Program, 5. Manufacturing PA Training-to-Career Grant Program, 6. Manufacturing Tax Credit Program

- Department of Environmental Protection grants include: 1. Alternative Fuel Cell Incentive Grant, 2. COVID-19 PA Energy Development Authority Restart Grants, 3. Driving PA Forward – DC Fast Charging and Hydrogen Fueling Grant Program, 4. FAST Act Corridor Infrastructure Program

<u>NJ State Grants</u>

- Department of Environmental Protection grants include: 1. Clean Communities Program Grants, 2. NJ Clean Construction Program, 3. Natural Climate Solutions Grants, 4. Petroleum Underground Storage Tank Remediation, Upgrade, and Closure Fund, 5. Hazardous Discharge Site Remediation Fund

<u>DE State Grants</u>

- Department of Natural Resources and Environmental Control includes grants from the Division of Air Quality as well as from the Division of Climate, Coastal, and Energy

<u>Hydrogen Laws and Incentives – PA</u>

PA Economic Development for a Growing Economy (PA EDGE / House Bill 1059): Details referenced in business plan.

The **Alternative Fuels Incentive Grant (AFIG) Program** provides financial assistance for innovative, advanced fuel and vehicle technology projects. Projects that result in product commercialization and the expansion of Pennsylvania companies are favored in the selection process.

<u>Hydrogen Laws and Incentives – NJ</u>

- NJ Department of Environmental Protection
    - Medium and Heavy Duty Zero Emission Vehicle Voucher Program
- NJ Department of Transportation
    - Bill A3904: Provides corporation business tax credits and gross income tax credits for purchase of certain hydrogen fuel cell vehicles
    - Bill A4111: Extends existing plug-in electric vehicle incentives to hydrogen fuel cell vehicles

New Jersey has developed an **Energy Master Plan (EMP)** that will guide the State to achieve its goals of electrifying the transportation sector and achieving 100% carbon-neutral electricity generation by 2050. The EMP calls for decarbonization of the transportation sector through:

- Supporting the deployment of 330,000 light-duty electric vehicles (EVs) by 2025;
- Deploying electric vehicle (EV) charging stations throughout the state, creating incentives for EV charging stations, educating consumers and fleet owners on EVs, and transitioning state fleet vehicles to EVs;
- Partnering with industry to develop incentives for medium- and heavy-duty all-electric or fuel-cell vehicles; and
- Exploring policies that accelerate the adoption of alternative fuels.

The **New Jersey Fuel Cell Task Force (Task Force)** was established to increase fuel cell use in the state, including fuel cell electric vehicles. The Task Force will support the growth of fuel cell companies, increase fuel cell use in state departments and agencies, develop a plan to expand fuel cell infrastructure, as well as provide information and educational resources to the public, government, and industry on the benefits of fuel cell technology. The Task Force must submit a report to the governor and the legislature within a year of its organization.

<u>Hydrogen Laws and Incentives – DE</u>

- Delaware Department of Transportation
    - Vehicle-to-Grid Energy Credit
    - Heavy Duty Natural Gas Vehicle Rebates
    - Electric Vehicle Supply Equipment Rebates

Alternative Fuel Tax Exemption: Taxes imposed on alternative fuels used in official vehicles for the United States government or any Delaware state government agency, including volunteer fire and rescue companies, are waived. Alternative fuel retailers must obtain a fuel supplier's license from the Delaware Department of Transportation (DelDOT), and operators or owners of vehicles using alternative fuel must obtain either a special fuel user's license from the Delaware Department of Transportation (DelDOT), and operators or owners of vehicles using alternative fuel must obtain a special fuel user's license from DelDOT.

Related Criteria

MACH2's geographic area has been historically a very industrial and skilled labor area, as referenced in the commercial feasibility section, with large presence in the chemicals, industrial and manufacturing spaces[21]. MACH2 leverages this strong industrial presence through utilization of existing pipeline infrastructure and networks that are currently or have been used by MACH2's included partners (e.g., PSEG, PBF, Monroe, etc.). In addition, the strong industrial presence decreases risk for project siting across the Hub. The states involved in MACH2 have unique characteristics that MACH2 will be leveraging to aid in its success. For example,[22]: Delaware has the fourth-highest concentration in the U.S. of PhDs working in health, science and engineering and the highest concentration of chemical engineers of any state. New Jersey is one of the states with the most expansive transportation and warehousing networks make it optimal for distribution as well as having some of the highest concentration of scientists and engineers in the world. NJ is also in the top 10 stats of installed solar capacity and solar jobs. Pennsylvania is one of the most economically diverse states in the country and the 6th largest economy in the US (with $915B GDP). PA also has a very business-friendly tax climate, with corporate net income tax rate being reduced to 4.99% by 2031.

As previously described and as it can be seen on Table 6, all the publicly owned partners present solid credit ratings from reputable credit scoring agencies such as Finch and S&P Global. Reflected publicly traded partners present competitive current ratios and ability to comply with short term obligations. All partners have expressed strong commitments and are able to leverage DOE financial assistance while ensuring the deployment of their non-federal cost share through any necessary funding sources. Risks associated with capital deployment and leveraging DOE financial assistance are registered by MACH2 and the team is actively working in mitigating actions.

Finally, MACH2's partners are all strong organizations both financially and through their experiences implementing large capital projects. They have all submitted letters of commitment to MACH2 and some key partners have also contributed financially to support

[21] Bureau Labor of Statistics
[22] Live Love Delaware; Pennsylvania Department of Community and Economic Development; Business.NJ.gov

MACH2 during the pre-application process (e.g., PSEG and PBF) as well as contributing their own in-kind and cost share amounts as they build and execute on their proposed projects. In this regard, MACH2 was selective with which organizations it pursued and ultimately selected to join the hub. The majority of these companies are well-funded, large publicly traded companies with access to capital and resources necessary to undertake large capital projects (as detailed previously above). They also have a strong history of large-scale project deployment as outlined in the Experience section above.

Other Selection Factors

In order to distribute the DOE funds most appropriately, production projects were evaluated based on a comprehensive framework including multiple criteria, such as their overall levelized cost of hydrogen produced, total capex funding needs, hydrogen volume, access to easily leveraged existing infrastructure, commercial viability, timing to production, and overall contribution to the Hub to advance the clean hydrogen economy in the region. Depending on how the projects performed against these criteria, a relative priority and a funding range of either 30%, 25% or 20% was assigned to the project. The MACH2 team used a bottom-up approach to estimate total funding to request from DOE through this FOA to ensure total request represented reasonable estimates and ultimately improved project economics to drive progress in clean H_2.

Projects that are more applicable to receive funding through other avenues were either not considered or only partially funded to support the advancement of the hub. For example, aspects of projects that proposed funding or capex allocated to truck fleet conversion were not considered for DOE funding through MACH2, given attractive credit incentives from the inflation reduction act (IRA) for the purchase of fuel cell electric vehicles through the clean vehicle credit from Section 30D. In addition, projects proposing hydrogen fueling infrastructure were designated as lower priority in comparison to other projects considered, given the alternative fuel refueling property tax credit in Section 30C.

Part 2: Engineering, Procurement, and Operations

Technology: The MACH2 Hub will be developed primarily using commercially available technologies for hydrogen production, storage, transport, and offtake. The production projects comprising the Hub will use commercially available equipment that has a proven operating track record in an industrial setting. Proton exchange membrane electrolysis, or PEM, has been in use for over 25 years and large-scale PEM systems have been offered since 2015. Alkaline electrolysis for both power generation and hydrogen production has been in use at large scale since the 1920s with the technology having matured through the 1980s. Hydrogen compressors are commercially available today with operating designs that meet the Hub project requirements; therefore, bespoke compression systems are not envisioned. The water treatment and hydrogen storage designs all exist and have been commercially in service for decades.

Vehicle hydrogen dispensing and refueling stations are relatively new and have limited operating hours for large-scale applications such as fueling heavy duty trucks. There is a minimal risk for the dispensing systems that do not meet the flow rates and filling times that are anticipated by the Hub projects but vendors such as NEL, Air Liquide, and Linde are actively designing and testing new fueling stations and components. Since this equipment will not be purchased or installed until 2024 / 2025 on a limited scale it is believed that most technological and operational challenges will be mitigated through continued development and testing by the manufacturers. The MACH2 Hub relies on an established power grid and power generation capacity that includes varied electrical production locations and sources (e.g., natural gas, nuclear, renewables). The hydrogen pipeline system envisioned for the MACH2 Hub consists of repurposing existing pipelines for hydrogen service either through replacement of steel pipes or upgrades using Smartpipe Technology into a primary transport corridor. Additional installation of new short to medium distance interconnector pipeline segments is required for specific projects. Commercially available steel pipe technology has been proven through decades of pipeline service and in-plant service. Key commercial technologies that will be used throughout the Hub and rated at DOE TRL 9 are listed below:

- H2 Production – commercial electrolyzer technologies including polymer electrolyte membranes (PEM), alkaline and solid oxide electrolysis cells (SOECs)
- H2 Consumption – commercial H2 fuel cells for transportation vehicles (buses, trucks)
- H2 Fueling – commercial fueling systems for bus and truck fleets
- H2 Transport and Storage - commercially available carbon and low alloy steel grades suitable for H2 pipelines and storage vessels
- H2 Compression – commercially available H2 compression equipment

The Hub includes monitoring non-commercial technology developments during Phases 1 and 2. Assuming commercial viability is proven, the Hub may invest in commercial scale projects in later phases. These currently non-commercial technologies include:

- Versogen anion exchange membrane (AEM) electrolysis currently rated at DOE TRL 6
- sHYp seawater electrolysis currently rated at DOE TRL 5
- Holtec International SMR-160 nuclear reactor
- Smartpipe Technologies fiber reinforced pipe (FRP) lining technology for hydrogen transport with built-in monitoring capability currently rated at DOE TRL 7

Table 7: List of MACH2 Technologies

Technology	TRL (DOE)	MACH2 Projects Partners
Proton Exchange Membrane Electrolyzers (PEM)	9	Chesapeake – Solar Electrolysis; Enbridge; PBF; PSEG; Holtec – Oyster Creek; Salem; Messer
Alkaline Electrolyzers (ALK)	9	Messer; PSEG; PBF
Solid Oxide Electrolyzers Cell (SOEC)	7	Holtec – Oyster Creek; Salem; PSEG
Anion Exchange Membrane Electrolyzers (AEM)	6	Versogen
Seawater Electrolysis	5	sHYp – BV PBC
Steam Methane Reforming (SMR) with RNG	9	PGW
Small Modular Reactor (Nuclear)	3	Holtec – Oyster Creek
Smartpipe Technologies	7	Enbridge

Versogen is expected to demonstrate AEM electrolysis technology in Phase 2 with a facility producing approximately 1.2 mt/day H2. Scale-up of the technology will take place over Phase2 and Phase 3 with commercial production of 24 to 40 mt/day in the time frame of 2029 to 2030 (Phase 3). Investment in scale-up activities from the Hub is contingent upon technology maturation. **sHYp** is expected to demonstrate its proprietary electrolysis technology utilizing seawater with a small demonstration plant in 2024, at a H2 production capacity of less than 0.01 mt/day. Scale-up of the technology will take place over Phase 2 and Phase 3 with commercial production of 4 mt/day anticipated in 2030 (Phase 3). Investment in scale-up activities from the Hub is contingent upon technology maturation. The **Holtec** International H2 production facility at Oyster Creek is expected to be operational in Phase 3 in 2032. This facility will use electrical power generated from Holtec International's new small modular nuclear reactor, the SMR-160, with commercially available electrolyzer technology. Nuclear Regulatory Commission (NRC) licensing and associated regulatory approvals of the SMR-160 reactor are required for the project to progress. The forecasted operational date of 2032 provides 10 years of development time, construction, and regulatory approval. **Smartpipe** Technologies is currently testing and seeking government approval for their FRP lining technology for use in refurbishing existing steel pipelines for the transport of hydrogen. The primary strategy in developing the MACH2 Hub's pipeline system is the use of existing hydrogen grade steel pipe technology for replacement of existing pipelines and for newly installed pipeline connectors. The approval of Smartpipe Technologies FRP pipe lining technology may offer a lower cost alternative to creating and expanding the MACH2 Hub pipeline system, or for refurbishing legacy hydrocarbon piping for hydrogen storage. Approval for use with H2 applications is expected in early 2024.

MACH2 will be built using commercially available technologies supplied by one or more suppliers in Phases 1 and 2. No intellectual property rights are expected to be purchased or licensed in conjunction with the proposed projects. Hydrogen generation by electrolysis is a commercially known process and most partners in the Hub will not be developing any new technology or processes within their Phase 1 or Phase 2 projects. Projects related to demand and offtake will use commercially available fueling and storage systems. Providers having proprietary technologies, sHYp and Versogen, will be constructing pilot facilities independent of the Hub. Once commercial viability has been proven, these providers are expected to participate in the Hub with commercial expansions. The Hub relies on several hydrogen producers utilizing a spectrum of commercially available technologies mitigating the risk of a particular technology impacting buildout of the Hub. Enbridge has an investment stake in Smartpipe Technologies and a proposed project within the Hub. Assuming approval of the Smartpipe Technology, Enbridge will offer the technology commercially or through a special licensing arrangement for the MACH2 Hub pipeline owners.

The MACH2 concept is assessed at a high DOE technology readiness level through early Phase 3. The Hub is assessed to have a DOE TRL of 9 at the integrated Hub level with individual projects having a DOE TRL of 7 to 9. MACH2 has access to an existing and extensive power grid and power generation facilities and an extensive existing pipeline network that can be refurbished and expanded through new pipeline connectors for hydrogen service. Facilities incorporating technologies currently at a TRL less than 7 are not expected to contribute significant H2 production capability to the Hub until Phase 3, beginning in 2029, providing a suitable time frame for technology maturation.

Technology readiness level scores for bothMACH2 Hub and the individual projects comprising the Hub were scored using the DOE Technology Readiness Level Scale. A TRL of 9 was assigned when a project utilizes all commercially available technologies and a commercial application of similar performance was identified (i.e., analog project). The Hub technology readiness level was weighted according to the importance of the project to the Hub's total projected production capacity for production projects, total demand for offtake projects, or transportation and interconnectivity importance for pipeline projects. Production facilities were weighted more than offtake and pipeline projects as they have the highest technology content of the three project types. Approximately 90% of end use demand is by consumers utilizing H2 in proven industrial or commercial applications.

MACH2 will be built using commercially available technologies supplied by one or more suppliers. Any technology maturation requirements are aligned with commercial production in Phase 3. Two technology developers and associated projects, AEM electrolysis by Versogen and seawater electrolysis by sHYp, have developed a multi-phased development approach starting with small demonstration facilities in Phase 1, SHYp, and early Phase 2, Versogen. Upon successful demonstration of the fully integrated technology as described under DOE TRL 6, each technology developer will execute a series of facility expansions through Phase 2 and Phase 3 to reach commercial production capacities. sHYp forecasts a 4 MT/day production capacity in 2030. Versogen forecasts a 40 to 60 mt/day production capacity in 2031.

The use of Smartpipe Technologies Fiber Reinforced Pipe (FRP) for hydrogen transport with self-monitoring capabilities through optic fibers for pipeline refurbishment is expected to receive DOE approval in early 2024. The pipe has been evaluated by the Department of Energy (DOE) and found to be compliance with the DOE's composite pipe standards. This technology is proposed for refurbishing existing hydrocarbon piping for H2 storage. It should be noted that existing commercially available steel pipe grades can be used for this purpose.

MACH2 will be built using commercially available technologies minimizing technology-based risks within the Hub. Technology-based risks that require management are risks that affect production and demand in early phases (1 and 2). The Holtec International Salem Hope Creek Hydrogen Generation Project (SHCHGP) is currently assessed at a TRL 7, as hydrogen production is proposed to be built adjacent to an operating nuclear facility, and potentially share a common control room with the nuclear reactors. The overall Hub risk management plan will also look to accelerate one or more production projects forecasted in 2027 or add newly defined projects as a contingency. The long timelines, on the order of 8 to 9 years, associated with the other technology developments and projects, Versogen and SHYp, allow for various risk assessment and mitigation points in the development timelines. Commercial production for these two technologies is forecasted in the time period 2029 to 2030.

Performance projections

Performance projections were done on a project level basis. Working with each project partner, detailed in the individual projects throughout the TEA, the overall production was estimated using corresponding technology and feedstock availability assumptions. Below are the generic assumptions we used for technology when estimates from partners were not available:

Table 8: Technology Assumptions

	SOEC (Nuclear)	PEM (Nuclear)	PEM (Renewable)
Electrolyzer efficiency	75%	75%	57%
Utilization	85%	85%	60%

Utilization assumptions consider availability of feedstock, downtime for maintenance and refurbishment. Electrolyzer efficiencies are based on numbers from DOE models as well as proprietary models built to model hydrogen production.

Figure 13 shows the overall production for the hub over the 30-year life of the hub. The estimates received from partners were assumed to be P50 production numbers. P50 values are suitable for budget estimation and cost allocation but will be further refined as engineering studies progress to receive P90 numbers which will be used to estimate overall PTC revenue and portray a more accurate picture on overall production. Overall, as described in the business plan, the hub meets the minimum threshold by 2027 with over 100 tons.

Engineering Design and Procurement

The MACH2 concept has been developed at a level commensurate with an engineering maturity of 5% to 10%. The overall hub configuration comprised of production facilities, pipeline transport systems, potential storage locations, and off-take demand locations has been identified including interconnectivity via the proposed pipeline network. This is shown in Figure 3 and 4. A portfolio of projects has been identified and included in the Hub with each project having an engineering maturity estimated at 5% to 20%. Each of these projects is further described in the TEA section of this document. Infrastructure requirements have been identified and initially qualified to supply power and water for the hydrogen production projects to be undertaken. Technical project descriptions, identification of technologies suitable for the projects, initial cost estimates, preliminary risk assessments and EPC project schedules have been defined for most of the projects considered in the MACH2 Hub concept. **In summary, the MACH2 partners have completed comprehensive conceptual designs for their projects commensurate with the four phased Hub development plan.**

The next step will be for the partners to complete their front-end engineering designs and engineering to complete all technical specifications, develop the project execution (EPC) scope of work, refine cost, schedule estimates, and prepare procurement plans with an emphasis on long-lead items as described in Phases 1 and 2 of the Hub Development Plan. These will form the basis of the project tender documents for the EPC phase. The EPC phase, Phase 3 in the Hub development plan, includes detailed engineering design, procurement of all the equipment and necessary materials, and construction to deliver a functioning facility or asset. Basics of the EPC process across all projects in the Hub portfolio are:

- Detailed design and engineering packages approved for construction.
- Develop final project cost estimates including both direct and indirect costs from engineering through to commissioning to set construction budgets.
- Develop final construction plans and schedules.
- Issue equipment specification packages and contractor work packages
- Procurement and delivery of equipment and selection of contractors
- Construction

- Commissioning and start-up

The principal process in the Hub is hydrogen production primarily through proven electrolysis technologies. Steam reforming using renewable natural gas (RNG) will be used for selected projects. These electrolysis technologies require water and power as process inputs. Heat replaces electrical power in the case of steam reforming as a process input. Water sources will depend upon the location but are presumed to be local municipal water or water from industrial partners. Depending on the location, power may come from a dedicated high voltage power line constructed from the power grid or directly from a nearby power plant or substation, the hydrogen production facility itself, or interconnection to the closest high voltage electrical power source. For producers using steam reforming heat input will come from onsite steam generation facilities such as electric boilers or boilers running on hydrogen or RNG.

The producers will either store the hydrogen production on site for transport and delivery via truck or produce directly into the Hub's pipeline network. Hydrogen production will be distributed among the identified production facilities in the Hub producing primarily green and pink hydrogen. Distribution will utilize an extensive network of new pipelines installed within the right-of-way of existing hydrocarbon pipelines, to connect anchor producers to end users. Specifically, a pipeline from Delaware City to Philadelphia, and associated connection to Marcus Hook Industrial Complex (PA). From there a hydrogen line will replace an existing line from Marcus Hook along the Inter-Refinery Pipeline (IRPL) to the new Bellwether district (PA). Additional production can be tied in at Paulsboro, New Jersey, and Fort Mifflin, Pennsylvania. Trucking will service smaller end users. See TEA Section for more detail and business plan for map of hub and infrastructure.

MACH2's key facilities are identified based upon their criticality to the success of the Hub. Criticality was judged by the relative production, delivery, or demand volumes to the hub. Th producers supplying greater than 12 mt/day and end-users greater than 10 mt/day are deemed to be key facilities. Two pipelines were also deemed to be key due to their large capacities and importance in Hub interconnectivity. These are shown in Table 9.
Most production facilities will use proven electrolysis technologies such as PEM and Alkaline electrolysis. Key facilities with technically complex components and requiring further technology development, such as Holtec International's new small modular reactor and Versogen's AEM electrolysis technology, are only considered in later phases of the Hub development plan. The two pipelines that form the backbone of product transport and delivery are key to the effective distribution of hydrogen and it is critical to have these pipelines ready for service per the planned construction and commissioning schedule.

Table 9: Key Facilities and Systems

Function	Phase	Partner - Project	mt/day	Technically Complex Component
Producer	2	Holtec - Salem Nuclear site	14	Technical integration of a hydrogen production facility with a nuclear power plant
	3	Holtec - Oyster creek	14	Use of nuclear small modular reactor, SMR-160, requires further permitting work
	2	Messer	28	
	2	PSEG - South Jersey	25	
	3	PBF - Delaware City	137	
	3	Versogen - Phase 6	60	Patented anion exchange membranes (AEM)

Function	Phase	Partner - Project	mt/day	Technically Complex Component
Delivery	2	Marcus Hook Connector and IRPL	200	IRPL retrofit requires lifting and re-laying of pipeline Marcus Hook to Twin Oaks Hub, PA – new 5-mile pipeline
	2	Delaware City to Philadelphia pipeline	75	Existing pipeline will be evaluated for replacement
End-user	3	Hilco - Bellwether District	250	
	2	DuPont	50	
	2	Monroe - Boilers	50	
	3	SEPTA	24	

The proposed technologies MACH2 partners are incorporating into their projects including their successful utilizations are shown below.

Table 10: Proposed Technologies and Successful Utilizations

Technology	Successful utilization
Proton exchange membrane (PEM)	This is a mature technology. Developed in the 1960s by General Electric. 2022 (Source: IEA Hydrogen projects database) Plug Power – (US), H2, FID, 49 mt/day Port of Aabenraa (DK) Methanol, FID, 20 mt/day Camden County (GA), green power plant (US), H2, under construction, 15 mt/day NY Science and tech park (US), H2, under construction, 49 mt/day
Solid Oxide Electrolyzers (SOECs)	Developed in the 1960s, however has been behind PEM in volume. Norsk e-Fuel Phase 1 (NOR), H2, FID, 14 mt/day (IEA Hydrogen projects database).
Alkaline electrolyzers	Alkaline electrolyzers have been in use since 1927. KIMA – Aswan (China) ammonia, decommissioned, 76 mt/day. Ben Tre project, phase 1 (Vietnam) H2, under construction, 139 mt/day Helios Green Fuels – Neom (Saudi) under construction, 1020 mt/day HYBRIT demo (Sweden) H2, under construction, 232 mt/day Sinopec - Kuqa (China) H2, under construction, 120 mt/day There are over 133 other hydrogen projects using this technology with a production total of 1,800 mt/day (IEA Hydrogen projects database).
Anion Exchange Membrane Electrolyzers (AEM)	Versogen is developing a pilot plant that will start in 2026 with production of 1.2 mt/day.
Steam Reforming (SMR) with Renewable Natural Gas (RNG)	This is a mature technology. SMR is the most common method used for producing H2. Almost 50% of global demand and 95% of US demand for hydrogen is produced by steam methane reforming. Methane can be fossil fuel derived or renewable derived (e.g., biogas).
sHYp Seawater Electrolysis	sHYp is developing their first pilot project with production of 0.01 mt/day commencing in 2025. The second pilot project with production of 0.04 mt/day commences in 2026 and the third pilot project has production of 0.4 mt/day in 2028.
Smartpipe Technology (For H2 Use)	This technology is currently used for pipeline repair/renewal for products other than hydrogen. Testing in H2 use has been performed at Savanah River National Laboratory (SRNL, USDOE).

Technology	Successful utilization
Holtec International Small Modular Reactor (SMR-160 nuclear reactor)	The US Nuclear Regulatory Commission (NRC) issued final rule certifying the first 50 MW SMR design in the US on February 21, 2023. Holtec has started pre-licensing interactions with NRC in Sept. 2022

The hub is a hydrogen marketplace where producers and end-users meet and negotiate bi-lateral sales and purchase agreements. These agreements form the basis of supply and demand across the Hub. MACH2 will work to match producers and end-users and balance supply and demand across the Hub. Many of the producers and end-users are integrating H2 storage into their facilities to buffer variations in supply and demand. The storage capacity will be driven by an assessment of risk to supply disruptions. The MACH2 team recognizes that it is important to design the hub with flexibility to absorb sudden changes to supply and demand. While producers will build storage for their own supply, options for larger storage available to the Hub are planned. For example, Enbridge proposes to repurpose existing large diameter crude and refined products pipelines by using Smartpipe technology to facilitate additional Hub storage.

The Hub has identified eleven partners as H2 suppliers and six off-take users. However, several additional projects for both production and off-take have been identified and are known to be in development within the Hub footprint providing additional resiliency and longevity. These additional facilities provide a peaking capability for high demand situations. This also provides an arbitrage opportunity for a third-party to buy, store, and sell hydrogen as the market fluctuates. In the longer term, MACH2 can connect with other H2 hubs or facilities outside the Hub's core to increase their resiliency. The primary feedstocks for hydrogen production are water and electricity. Many of the producers are sourcing water from established local municipal or industrial entities providing a robust supply source. Also, many producers are relying on electrical power from the grid through power purchase agreements (PPAs) resulting in high electric availability and reliability. The grid servicing the Hub is supplied by power generated through natural gas, nuclear and renewable energy.

Procurement will be managed by the individual partner projects. A typical procurement process starts with an engineering design package that details the specifications of the product or service to be delivered, that is then turned into a bid package issued to qualified suppliers. The procurement strategy must accommodate long lead items such as electrolyzers, compressors, storage, and electrical equipment as these have been identified as critical long lead items in hydrogen production. The critical lead time items are anticipated to be electrolyzers and large volume storage tanks. The electrolyzers have a lead time of 12 to 20 months depending upon size. Storage lead time is similar with 12 to 20 months. Due to the long lead equipment, the procurement plan may have to start in early design stages to have it available in a timely manner during construction.

MACH2 partners have identified potential or planned suppliers of major equipment including electrolyzers, power as shown in Table 11, Potential or Planned Suppliers. Note that all technologies have one or more suppliers with US based manufacturing capacity to comply with "Build America, Buy America Act" requirements.

Table 11: Potential or Planned Suppliers

Technology	Suppliers
Proton Exchange Membrane (PEM) Electrolyzers	Plug Power, Versogen, Bloom Energy, Ohmium, Cummin, ITM Power Siemens, NEL
Solid Oxide Electrolyzers (SOECs)	Bloom Energy, OxEon Energy, Plug Power, FuelCell Energy, Cummins, Nexceris
Alkaline Electrolyzers	Longi, John Cockerill, Thyssenkrupp, Auyan, HydrogenPro, NEL, Sunfire, McPhy
Anion Exchange Membrane Electrolyzers (AEM)	Versogen, Alchemr
Steam Methane Reforming (SMR) (RNG feedstock)	Air Products and Chemicals, McDermott, Air Liquide, Honeywell UOP, Heurtey Petrochem, KBR
sHYp Seawater Electrolyzers	sHYp
Smartpipe Technology (For H2 Use) Pipe repair/renewal	Smartpipe Technologies
Small Modular Nuclear Reactor	Holtec International

Most, if not all, partners will use third-party contactors in the engineering, procurement, and construction phases. Services would include engineering and design, project management, construction (e.g., civil, mechanical, piping, electrical), labor, equipment rental, transportation. These will be provided in third-party contracting plans developed by the projects.

MACH2 and its partners will leverage US manufacturing and supply chains in their construction plans in support of the "Build America, Buy America Act". Specifically, this applies to iron and steel, manufactured products, and construction materials. This will flow down to all subcontractors as appropriate. Many electrolyzer manufacturers have plants located in the US including Cummins, Plug Power Bloom Energy, HydrogenPro, and FuelCell. US vendors supplying the key technology required for these projects are noted in Table 11. MACH2 partners will prioritize and utilize US vendors to the maximum extent possible. Recent estimates show that within PA and NJ, 600,000+ people are employed within the natural gas and oil industry and stand to benefit from skills training, workforce redeployment and development, and career advancement opportunities associated with growing and emerging clean energy industries. The MACH2 Hub project will provide multiple opportunities to retrain, redeploy, and develop high value trade, craft, operations, and other skills. It is recognized that hydrogen hubs developed concurrently across the US will put a strain on US supply chains for selected types of equipment (e.g., electrolyzers) and materials (e.g., H2 compatible steel alloys) which will be addressed as a procurement risk. MACH2 presents an opportunity to coordinate within the portfolio of projects to leverage aggregated procurement of critical items.

Cost Estimates: Cost estimates were developed in accordance with partners and at the requested class 4 level, all costs listed are in line with 5% engineering design with costs falling in line with +40% to -30%. Throughout the TEA project descriptions, detailed cost estimates are provided including CAPEX, OPEX and overall construction costs. Cost estimates were produced using the methodology provided at the beginning of the TEA. The total project costs of the hub including 2 years of operating expenses and financing costs are detailed in Table 12 below.

Table 12: MACH2 Total Project Costs

	TPC ($M)
CAPEX	2,724.01
OPEX (Fixed, Variable and Energy)	813
Financing costs	8.1

Execution Schedules

MACH2's Integrated Project Schedule (IPS) integrates the portfolio of projects in the Hub and coordination of Hub level activities such as the Community Benefits Program and Regulatory and Permitting Program (PEIS). This schedule Level 1 and Level 2 detail for such activities as technology maturation, engineering, design, procurement, construction, and other activities. The complete schedule is provided in Part 6: Workplan. A summary of this schedule is provided showing phase, projects, milestones and start of H2 production by phase in Table 13.

Table 13: MACH2 Hub Integrated Project Schedule Milestone Summary

Milestone or Task	**Start Date (Duration from DOE Award)**
DOE Award of Phase 1	Jan. 8, 2024
Phase 1	
Phase 1 First Commercial Production Start-up	18 Months
Phase 1 End Users Established for Initial Offtake	17 Months
Phase 2	
Pipeline Transport Backbone	52 Months
Phase 2 First Commercial Production Start-up	36 Months
Phase 2 End Users Established for Initial Offtake	51 Months
Phase 3	
Additional Pipeline Connectors	91 Months
Phase 3 First Commercial Production Start-up	73 Months
Phase 3 End Users Established for Offtake	54 Months
Phase 4	99 Months

Operating and Disposition Plans

MACH2's operational role will be to facilitate the balancing of supply and demand at a macro level in the early phases through strategic funding allocation to ensure that current and future hydrogen production, demand, and transportation needs for the region can be met. MACH2 will also ensure assets will be ready for utilization shortly following their construction, through continued monitoring of production, storage, and distribution assets coming online at the same pace of demand. This follows the philosophy used during the planning stage of pursuing a combination of projects for production, distribution, storage, and end use that acts in concert to maintain a robust and reliable Hub operation.

The producers and end-users will establish sale and purchase agreements for the delivery of hydrogen. In the future storage providers will develop large storage capacity to allow arbitrage opportunities to balance supply and demand. Such opportunities will also be available once the MACH2 Hub interconnects with other regional hubs.

The project partners will be responsible for decommissioning or redeploying their assets. Typically, prior to the end of life of the asset, planning starts on how to decommission or redeploy the asset in such a way that is environmentally conscious and in the best interest of the community and region at large. The key decision is how will the facility site be reused. This could include repurpose to industrial use or redeploy using a new hydrogen technology. This impacts the amount of remediation needed and decommissioning or redeployment plans. While it is envisioned many of these sites have long term use with periodic upgrades to extend their life, some will need to be decommissioned. These plans will include cleaning and removal of processing equipment, recycling components such as electrolyzers, piping, electrical components, mechanical devices, and storage tanks. Once the site is clear, the remaining infrastructure, including buildings, roadways, utility services, could be evaluated for repurposing, demolition, or left in place.

Part 3: Safety, Security, and Regulatory Requirements

Safety: MACH2 management firmly believes that safety, security, and environmental and regulatory compliance, are essential elements of successful hub development. MACH2 management will espouse and enforce a culture of safety among all members of MACH2 for all aspects of hub development. The MACH2 team will select a Safety Program Lead, and management will also enlist a qualified engineering safety consultant(s) to ensure that every aspect of safety, environmental and regulatory compliance is addressed and executed by project developers and MACH2 management for the overall hub.

MACH2 is fortunate to have large companies with significant project development and operational experience engaged to construct and operate production, distribution, and end use assets. Each has a sharp focus on and gives highest priority to safety, security, environmental and regulatory compliance. All but the developing technology companies (sHYp and Versogen), have demonstrated successful large-scale development. Their respective policies on safety and security are included in this application. The MACH2 Safety Lead will coordinate with project developers to ensure that each site has a safety plan for all phases of development that will include HAZOP analysis. Operational safety procedures will also be documented.

MACH2 management recognizes that education and training of labor and first responders on the safe handling and transport of hydrogen is essential to success. Prior to the end of Phase 2, MACH2 will present specific plans for safety training that may incorporate the R&D facilities of Chemours, Air Liquide and DuPont as well as the state of the art (former Exxon) laboratory at Paulsboro that PBF has agreed to allow Rowan and other academic institutions use as well as Chesapeake Utilities' state of-the-art "Safety Town" training center in Dover, DE, offered as a site to conduct training. This training will be in place prior to the end of Phase 3.

MACH2 management (together with Labor & Safety leads) will develop a plan and coordinate safety training to ensure all relevant organizations have the necessary knowledge and skills to safely develop a hydrogen economy. MACH2 management (together with Community Benefits & Safety leads in coordination) will develop a plan to coordinate outreach to first responders and their respective communities. MACH2 management strives for continuous improvement and welcomes reviews by the Hydrogen Safety Panel, or the hub will seek independent reviews to ensure that best methods and technologies are employed.

All facilities in MACH2 will participate in the collection and submission of safety related data during the period of DOE project funding and continue to do so voluntarily for five years after the DOE award's end date. Open communication about the safety and lessons learned within MACH2 participants, as well as with external regulators, can contribute to the risk assessment and codes and standards development, fostering a sustainable hydrogen safety culture. MACH2 participants will notify DOE of any safety event in a timely manner and communicate any root cause investigation and mitigation effort. Additionally, hydrogen-specific safety events will be made public through the Lessons Learned database at H2Tools.org. MACH2 management will work with the Center for Clean Hydrogen (CCH) in implementing the safety data requirements. CCH is a 25,000 ft^2, $30+ million funded state-of-the-art facility at University of Delaware (UD) in partnership with Chemours, Plug Power, and the National Renewable Energy Laboratory. CCH brings to MACH2 the hydrogen related Environmental, Health, and Safety (EHS) expertise through its partnership with globally leasing hydrogen technology companies. CCH will also help MCH2 hydrogen producers to qualify electrolzyer stacks and component at commercial MW scale. This shared facility saves MACH2 producers time and money and enables them to move their technology faster to the market. CCH will build a close relationship with testing partners in safety related data collection and root cause analyses. With the testing facilities and service open to all MACH2 participants, CCH is well positioned in developing and maintaining evidence driven H2 safety knowledge base for the MACH2 community.

Cybersecurity

MACH2 Management recognizes Cybersecurity risks defined as:

- A cyber-attack resulting in the loss or disclosure of information (e.g., a data breach).
- A cyber-attack resulting in the unavailability, disruption, or loss of key functionalities in process equipment and infrastructure.
- A cyber security event resulting from a near-miss, such as circumventing policy or controls.

Except for the new technology companies (sHYp & Versogen), MACH2 hydrogen production project developers are large companies engaged in energy production and common carrier distribution for electric power, natural gas, petroleum and/or nuclear power and they have already implemented robust cyber security policies mandated by Federal Agencies such as Transportation Safety Administration and the Nuclear Regulatory Commission. Although this fact is of some comfort, MACH2 management will aggressively pursue and coordinate over all hub cyber security risk mitigation, engaging external cyber security expertise and in coordination with the relevant operating entities review all aspects of hub operations to identify and address cyber security vulnerabilities. MACH2 knows the importance of ensuring that cyber security is incorporated into new devices, systems and infrastructure at the "security by design" for new equipment, apparatus and components is critical to cyber risk mitigation. MACH2 will be prepared to present its initial cyber security plan specific to and address unique aspects of MACH2 during the award negotiations phase and will further refine the plan to achieve a final plan before the end of phase 2.

Permitting & NEPA

Assumptions: Given that the grant funding will come through U.S. Department of Energy (DOE), we anticipate that the DOE will guide the National Environmental Policy Act (NEPA) process and will assume the role as lead agency. This may be done in coordination with another agency, but the key role for NEPA approvals will likely come through the DOE. Due to the complexity of the interacting projects and the need to assess the cumulative impacts and develop a comprehensive alternatives analysis, we anticipate for scheduling purposes, that an Environmental Impact Statement (EIS) will need to be prepared for the Hydrogen Hub Project. Given the vast area of coverage involving several states and numerous project locations, the EIS most likely should take the form of a *Programmatic EIS* (PEIS). A PEIS will also afford the flexibility of adding additional projects to the Hydrogen Hub Project.

Additionally, the PEIS allows for a tiered approach where subsequent project-specific environmental analyses can be undertaken pending project elements, geographic location, and environmental issues. For example, project specific issues at different stages can be broken into large regional issues. This may allow more flexibility to permit existing facilities and infrastructure and allow the addition of new facilities over time. For example, a PEIS may allow for a program of projects, such as those involving existing pipeline, storage and production facilities that are undergoing conversion, and perhaps are covered by a Categorical Exclusion (CX), to proceed on a fast track. Projects for new infrastructure with needs for additional analyses such as Environmental Assessments (EA) or supplemental EIS, new rulemaking or technical analyses will proceed at a different pace. A tiered approach encourages the elimination of repetitive discussions and allows for more focus on issues ready for decision at each level of review. Further, different types of avoidance, minimization, and/or mitigation measures can be created to streamline subsequent environmental reviews for similar project types. The proposed schedule below is presented as a maximum amount of time required for each step in the NEPA PEIS process. Expediting the PEIS process could allow projects involving existing facilities to get into production faster.

Proposed Schedule

The proposed schedule in Table 14 correlates milestones and deliverables and is based on the federal agency requirement to analyze potential project related effects on the environment. In some instances, environmental analysis, applicable mitigation, and permitting reviews can be conducted concurrently to streamline the overall project review process. The NEPA process is anticipated to require approximately **two years** for completion based on Federal regulations (40 CFR 1501.10). Subsequent permit reviews and agency approvals may extend an additional nine (9) to twelve (12) months out from the NEPA process.

Table 14: proposed milestone tasks and deliverables for nepa peis

Milestone Tasks & Deliverables	Max Workdays from NTP	Max Months from NTP
Initiation for Environmental Review (3 months)		
Notice to Proceed		
Project Scoping and Scheduling	20	1
Notice of Intent (Publish in Federal Register	40	2
Agency & Local Official Coordination for NEPA (24 months)		
Range of Alternatives for Analysis	160	8
Technical Studies / Assessment of Affected Environment	360	18
Public Notice & Hearing	460	23

Final Environmental Impact Statement	500	25
Record of Decision (Publish in Federal Register)	540	27
Regulatory Permitting (Time Dependent on Agency Reviews)		
Environmental Permitting Pre-Application Workshops	520	26
Completion of Permit Applications	540	27
Permit Approvals (Dependent on Agency)	680	34

Permitting Risks

There are inherent risks in any planning process, especially for new projects with emerging technologies which need to be demonstrated prior to full permitting. Some technologies and systems, such as new hydrogen pipelines, may be subject to new rulemaking that is currently not underway. This could result in project delays; however, a delay could be accommodated by the tiered PEIS approach. For projects that may require mitigation considerations, delays may be caused by availability of mitigation resources or if mitigation sites need to be created. Given the nature of many of the industrial sites in the project area, there could be an unknown risk of delay due to the project being in the vicinity of contaminated sites or Resource Conservation Recovery Act (RCRA)/Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites which would require additional coordination and perhaps modifications of existing permits and agreements. This may also apply for certain ongoing permitted activities that would need to be updated due to proposed plans for newly constructed facilities.

The Hydrogen Hub Project is in a heavily populated urban environment where socio-economic considerations will need significant investigation to ensure equitable treatment of sensitive and vulnerable populations. Additionally, there are numerous historic sites and districts located in the vicinity of the project area, and regulatory review for historic and cultural resources under Section 106 of the National Historic Preservation Act (NHPA) can require extensive research and often cause significant delays in the NEPA and permitting processes. The new facilities located on waterfronts will need careful coordination with the U.S. Army Corp of Engineers (COE), especially Section 408 review under 33 USC 408 for consistency with ongoing federal projects. In addition, the replacement of the Inter-Refinery Pipeline (IRPL) will require permitting from the COE as there are river crossings of the Delaware River

The risk of lawsuits from NGO's or citizen groups could be high given the location of many of the facilities. We anticipate this risk could be mitigated by using the PEIS process and include stakeholders early in the process to address concerns about the project. We have drafted a proposed schedule for the project for a two (2) year NEPA review for developing the PEIS, in accordance with Title 40 CFR 1501.1, which specifies that there is a two (2)-year time limit on the EIS process from the Notice of Intent (NOI) to Record of Decision (ROD). However, we anticipate there is a substantial risk that this project could be extended for additional time.

Applicable Federal and State Agencies: The list below represents the federal and state agencies that will have authority over activities and resources in the project area but may not be a complete list of other agencies with review capacity for the project.

Table 15: Federal and State Agencies with Permitting Authority

Federal	Environmental Protection Agency (EPA)
	Department of Energy (DOE)

	Department of the Interior (DOI), Fish and Wildlife Service (FWI), National Parks Service (NPS), Bureau of Indian Affairs (BIA)
	Department of Transportation (DOT), Pipeline and Hazardous Materials Safety Administration (PHMSA), Federal Aviation Authority (FAA), Federal Railroad Administration, Maritime Administration (MARAD)
	Department of Defense (DOD), Army Corps of Engineers (COE)
	Federal Energy Regulatory Commission (FERC)
	National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Coastal Zone Management (CZM)
	Nuclear Regulatory Commission (NRC), Atomic Energy Safety Board (AESB)
	Occupational Health and Safety Administration (OSHA)
Delaware	Delaware Division of Historical and Cultural Affairs
	State Historic Preservation Office (SHPO)
	Department of Natural Resources and Environmental Control (DNREC)
New Jersey	Department of Environmental Protection (NJDEP)
	Office of Natural Resources
	State Historic Preservation Office (SHPO)
Pennsylvania	Department of Environmental Protection (PDEP)
	PA Historical and Museum Commission
	State Historic Preservation Office (SHPO)
	Department of Conservation and Natural Resources

The DOE is funding the Hydrogen Hub Project and anticipated to assume the role as lead agency. The DOT's PHMSA is a national program to ensure the safe, reliable, and environmentally sound operation of the nation's natural gas and hazardous liquid pipeline transportation system. The PHMSA issues special permits and state waivers. The EPA, FWS, and NOAA NMFS are anticipated to have a role in agency approvals, concurrence, and permitting. Both FWS and NOAA NMFS will be interested in potential impacts to threatened and endangered (T&E) species that are protected under the Endangered Species Act (ESA) and/or the Marine Mammal Protection Act (MMPA). NOAA NMFS may issue incidental take authorizations under the MMPA, when applicable. The EPA will also have an authoritative role concerning RCRA and CERCLA sites. Additionally, if part of the project alignments is located near an airport, then coordination with the FAA is needed regarding any construction or alterations which may affect navigable airspace. In addition, the replacement of the Inter-Refinery Pipeline (IRPL) will require permitting from the COE as there are river crossings of the Delaware River.

Table 16: Permitting by Project Type

Project	Type	Primary Permitting/Regulatory Considerations	Anticipated NEPA Document
In-State H2 Transportation Pipeline	New Build	States, DOE PHMSA, FERC	Environmental Impact Statement (EIS)
In-State H2 Transportation Pipeline	Revamp Existing	States, DOE, FERC, EPA	Categorical Exclusion (CX)
In-State H2 Transportation Pipeline	Replace	States, DOE, FERC, EPA, ACE	Environmental Assessment (EA)
Interstate H2 Transportation Pipeline	New Build	States, DOE PHMSA, FERC	Environmental Impact Statement (EIS)

Project	Type	Primary Permitting/Regulatory Considerations	Anticipated NEPA Document
Interstate H2 Transportation Pipeline	Revamp Existing	States, DOE, FERC, EPA	Categorical Exclusion (CX)
Interstate H2 Transportation Pipeline	Replace	States, DOE, FERC, EPA	Environmental Assessment (EA)
Hydrogen Production Facility - Green (Electrolysis)	New Build	States, DOE, EPA	Environmental Impact Statement (EIS)
Hydrogen Production Facility - Pink (Electrolysis)	New Build w/ tie-in to Nuclear Power	States, DOE, EPA, NRC	Environmental Impact Statement (EIS)
Hydrogen Production Facility - Orange (SMR)	New Build (Renewable Natural Gas)	States, DOE, EPA	Environmental Impact Statement (EIS)
H2 Fueling Station	New Build	States, DOE, EPA	Environmental Impact Statement (EIS)

Part 4: Risk Analysis and Mitigation

During Phase One of the project several key aspects will be set up. First, the risk management approach will be established detailing how the MACH2 team will identify and assess risks as well as how responses are planned and implemented with communication guidelines. MACH2 will also establish risk tracking, escalating and mitigating processes. Risks can be both negative and positive, and ensuring that that each risk is understood is vital to the establishment of an effective risk management process. An assessment process will be created to identify risks that might have a material impact on the overall viability of individual projects and the MACH2 hub as a whole. A risk register will be established that will be used to identify and record identified risks and corresponding decisions for mitigation. Over the course of the hub's lifespan two key products will be created and maintained: (1) a risk management approach that will describe the processes to manage risk, and (2) a risk register as discussed above.

Additionally, a dedicated risk budget or contingency will be reserved to fund specific management responses to different project threats and opportunities. In order to determine this budget, individual projects will identify and quantify risks. The simple sum of the potential cost will be used as a baseline for simple projects. Below is an initial broad overview of potential risks, probabilities and mitigation steps. As the risk register is developed, this view will be updated and expanded to ensure a holistic perspective when managing risks across the MACH2 program and all project partners. Risks assessments will be supplemented with quantitative evaluations as needed.

Table 17: Preliminary Risk Register

Commercial Risk	Probability	Impact	Mitigation steps
Technology does not meet required TRL by stated timeline	Low	Low	Considered any TRL6 projects as supplemental to overall initial market potential, and considered in later phases
Projects cannot find offtakers	Medium	High	MACH2 designed with optimization of production and offtaker groups to minimize overall hydrogen

			costs from production and delivery to ensure longer term feasibility
Project LCOH falls outside of original class 4 estimate	Medium	High	Continuously monitoring project and variable costs early
Multiple projects fail to get built or meet stated max production	Low	Medium	MACH2 has multiple well-financed and publicly traded companies as producers to diversify risks

Technical Risk	Probability	Impact	Mitigation steps
Development of fuel dispensing systems is delayed or unable to accommodate the flows and filling times required for the project.	Medium	Low to Medium	Engage with engineering companies and manufacturers early. Visit manufacturing factories and operational sites to see firsthand the state of the equipment
Risk of technology performance failure or delay in technology development scheduled for technologies having a TRL of 7 or less may impact later phases of Hub	Medium	Low to Medium	Technology development plans to be monitored with periodic technoeconomic reviews and milestones. Replacement projects for hydrogen production capacity at risk to be identified as contingency production capacity
Interface of hydrogen production systems and facilities with existing power generation facilities	Low	Low	Develop comprehensive design and operating between the two facilities
Due to number of sites storing and handling hydrogen, potential for fire or explosion risks near population center(s)	Low	Medium to High	Each project and key infrastructure point must be designed with safety principles at forefront and include appropriate gas monitoring and other safeguards

Construction Risk	Probability	Impact	Mitigation steps
Design and engineering requires additional review due to "new technology" facilities.	Medium	Medium	Design and engineering management plans should account for additional technical, operating, and safety reviews. Learnings from analog projects should be incorporated into design and engineering.
Shortage of skilled work force to perform projects given number of projects in Hub project portfolio.	Low	Low to Medium	Regional labor force plan to be developed. Regional contractor survey to be undertaken.
Existing infrastructure not suitable for intended use within Hub infrastructure.	Low	Medium	Front-end engineering studies to be undertaken to qualify existing infrastructure. Contingency plans for existing infrastructure to be developed if required.

Schedule Risk	Probability	Impact	Mitigation steps
Procurement of critical infrastructure equipment, long lead equipment for production facilities, pipelines and fueling stations lead to schedule delays	Medium	Low to Medium	Front-end engineering plan to be developed to provide additional clarity on schedule risk and revisit overall timeline
NRC review/approvals of the H2 generation systems, structure and components adjoining nuclear facilities	Medium	Medium	Permitting plan for each facility to be developed with additional time added for permitting around hydrogen specific permits.
Integrated project schedule includes a Programmatic	Medium	High	Front-end engineering plan to be developed to provide additional time for D&E activities.

Environmental Impact Statement (EIS). If coordination and agreement between agencies and states is not obtained in a timely manner this may impact the individual project execution duration and cause schedule delays.			
Design and engineering execution delays risk for critical facilities, pipelines, fueling stations and other projects.	Low	Medium	Front-end engineering plan to be developed to provide additional time for D&E activities.
Project execution start date and schedule delays due to permitting approvals.	Medium	Medium - High	Permitting plan for each facility to be developed with additional time added for permitting around hydrogen specific permits.
Project execution start date and schedule delays due to timing of funding and/or financing decisions.	Medium	Low to Medium	Front-end engineering plan to be developed to provide additional clarity on schedule risk and revisit overall timeline

Permitting Risk	Probability	Impact	Mitigation steps
Regulations and permitting procedures / requirements are not developed in time to execute to project schedules.	Medium	High	No mitigation plans required at this time. Additional time should be built into early project schedules or probabilistic schedules developed to account for such regulatory delays.
Regulations and permitting procedures / requirements change immediately before or during project execution.	Medium	Medium	Additional time should be built into early project schedules or probabilistic schedules developed to account for such regulatory delays.
Project is not able to obtain approved permits.	Medium	High	Permitting analysis and early engagement with regulating and permitting agencies as part of front end project planning.

Safety Risk	Probability	Impact	Mitigation steps
Accident or injury during construction of plant	Low	Medium	Securing documentation from our project partners, e.g., HSSE plans that detail strategies to reduce safety risks. MACH2 will reach out to first responders during early phases to define action plan in case of accidents
Accident due to new pipeline hydrogen infrastructure being built	Low	Medium	Pipeline infrastructure is owned and operated currently by companies who have long industrial experience and understand the safety risks and subsequent mitigation measures needed
Accidents from bulk handling of hydrogen	Low	Medium	Majority of project partners are well versed in handling industrial gases. Newer companies will seek necessary training and certifications needed, with MACH2 establishing working groups for safety trainings (e.g., Safety town). MACH2 has selected companies with a culture of safety.

Scale-Up Risk	Probability	Impact	Mitigation steps
Selected electrolysis technology does not scale	Low	Low to Medium	Replacement H2 production projects or contingency hydrogen production capacity to be identified.

Infrastructure Risk	Probability	Impact	Mitigation steps
Lack of connected infrastructure to move, store, and receive hydrogen	Low	High	Providing multiple methods of product evacuation from production sites and alignment in timeline of production and use needs. Leveraging existing rights of way to lay new hydrogen infrastructure on time to meet needs.
Existing infrastructure is not suitable for retrofitting for transport or storage	Low	Medium	Studies have already been done on identified technology on similar pipe specifications available for retrofitting in the MACH2 hub. Above ground storage has also been identified for construction on project sites.
Delays in renewable procurement or capacity build up timeline	Medium	High	Conversations with PPA providers have already begun to mitigate issues heading into Phase I/II of not having available PPAs. Some projects are planning to build their own renewable energy generation and have risk and contingency built into project timelines and costs to account for delays. Project partners proposing small generation projects will plan to avoid PJM's level 4 interconnection to avoid interconnection queue.
Delays in electrolyzers, other equipment and materials	Medium	High	Many projects are using providers of electrolyzers that have local production sites in Delaware as well as for construction (e.g., Bloom and Versogen). Project partners are also using a diversified set of electrolyzer manufacturers to mitigate risks.
Identified sites not suitable for construction	Low	Low	Most submitted projects are using sites either already controlled or vetted by the site owners for their feasibility for the project. Project sites are currently industrial sites with existing infrastructure, having already been used for prior projects.
Existing infrastructure not suitable for intended use within Hub infrastructure. (e.g. power grid, power demand, water supply)	Low	Low to Medium	Front-end engineering studies to be undertaken to qualify existing infrastructure. Contingency plans for existing infrastructure to be developed if required.

Financial Risk	Probability	Impact	Mitigation steps
Cost share funding does not materialize from partner	Low	High	MACH2 chose financially reliable partners and has a diversified portfolio of projects.
PTC from IRS is reduced, or delayed	Medium	High	MACH2 to ensure measurement of production is in line with standards to be eligible for more stringent PTC requirements.
Partners LCOH higher due to tax inefficiencies	Medium	High	Work with project partners to identify tax partners as needed. MACH2 designed with optimization of production and offtaker groups to minimize overall hydrogen costs from production and delivery to ensure longer term feasibility
Partner projects are at much higher capex and opex costs than estimated in application phase	Medium	High	Work with partners to lock in supply and energy contracts and financing as early as feasible. Look into locking in agreements at scale for similar technologies from a consolidated list of vendors. MACH2 to set up PMO with project control and governance mechanisms.

Insufficient funding available for capital improvements resulting in misalignment of supply and demand of hydrogen	Medium	Low to Medium	Co-ordinate across project portfolio to help identify potential synergies between projects where cost savings through common contractors or materials may be achieved.

Management Risk	Probability	Impact	Mitigation steps
Loss of key personnel during initial phase	Low	Medium	Key personnel during pre-application and application phase will stay on with MACH2 either in new roles or as advisors.
Organization does not have expertise to execute effectively	Low	High	MACH2 is hiring its executive level management team specifically looking for industry expertise and plans to have special advisory committees throughout the phases to advise on specific topics.
Not in compliance with DOE requirements	Low	High	MACH2 has put a management plan in place that outlines and tracks the key milestones and performance indicators needed to be achieved in order to be eligible for DOE funding and be in compliance with requirements. MACH2 has engaged personnel that have experience in fulfilling DOE FOAs and grants.

Organizational Risk	Probability	Impact	Mitigation steps
Organizational structure not large enough or equipped to handle multiple project partners	Low	High	MACH2 leveraging professional services and hiring and internal team to establish comprehensive project management across partners and projects.
Project management insufficient to execute successfully	Low	High	Project management team will be put in place to coordinate across functions and project partners, monitoring KPIs and milestones.

Market Related Risk	Probability	Impact	Mitigation steps
Market for hydrogen slow or non-existent	Low	High	Working with demand partners to educate and inform about hydrogen use and develop acceptable economics through working groups across the hub.
Offtake partners asking for too low a price / demanding too high a price for production	Medium	High	Hub designed with matching production and offtake partners in mind to ensure long term agreements and stability. Internal price competition and learning curves expected to help keep prices in willingness to pay range.

Part 5: Technical Data and Analysis

Preliminary TEA

<u>Hub overview</u>

MACH2 will consist of 11 production projects with 44 miles of pipeline (additional 11 miles under consideration to increase connectivity) and 45 mt of storage ramping up over a 30-year period, which represents 17% of daily production in 2032 (additional above ground storage being considered). In order to support and demonstrate the financial viability of the MACH2 hub, a preliminary techno-economic analysis was undertaken. In Figure 11 below you can see the overall process for the analysis design.

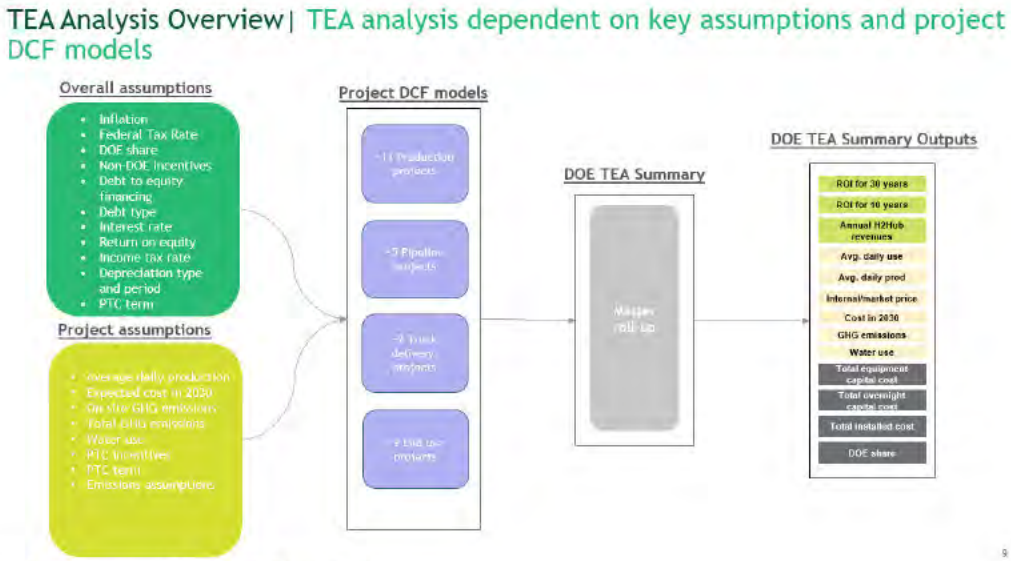

Figure 11: Technoeconomic Analysis Overview

Working with project partners, estimates for each project were collected. These estimates, along with assumptions to fill in the gaps, were used to model each project using a discounted cash flow model incorporating GAAP accounting principles over a 30-year lifespan. Each aspect of the hub was modeled as a separate entity with its own cash flows. These include production, end use, storage, and transportation. Each cash flow was then pulled into a master roll up that was used to look at the overall cash flows for the hub. In table 18 you can see the expected rate of return for the hub over 10 years and 30 years. For all rates of return, the value expressed is in pre-tax unlevered IRR. In evaluating the projects, the unlevered pretax rate is used to ensure consistent assumptions across projects. Each of the project partners has a different tax situation and how they will recognize the depreciation of the assets over time introduces multiple complications that cannot be fully demonstrated in individual project finance models. These values assume that each company is tax efficient and can utilize depreciation at the time they recognize it, leading to a maximization of tax benefits. It will be difficult for all companies to be tax efficient, and many will have to explore joint ventures or delayed realization of tax benefits which is why the pretax IRR is the preferred metric used when considering the financial viability of each project.

Table 18: Pre-tax unlevered IRR for the hub over 10 and 30 years

	Value
[redacted]	[redacted]
[redacted]	[redacted]

Additionally, in Figure 12 the overall cost contribution between Production, Transportation, Storage and End use is shown.

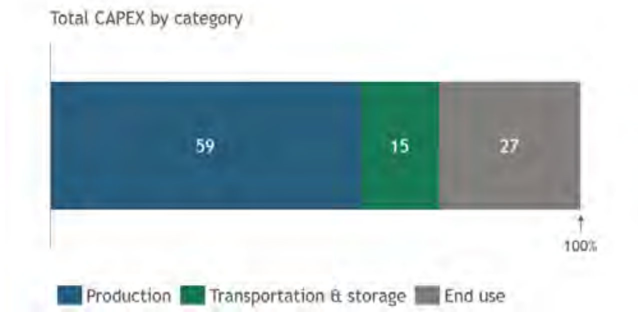

Figure 12: Breakdown of DOE funding by the three main categories evaluated.

The TEA and LCA spreadsheet lists the overall values for the hub. To calculate those summary values, a weighted average was used based on production. While this will not be as accurate as individual project modeling, it provides a sufficient estimation for the current stage of the hub and overall accuracy of the financial projections. Overall, the hub achieves investor's desired rate of return while producing acceptable prices based on off taker's pricing desires or willingness to pay. Ultimately, the final pricing will be subject to a competitive process that will drive prices down and create a competitive market, ensuring that the DOE funding is maximizing the value for the hub. Figure 13 shows how demand and supply ramp up over time.

Figure 13: Hydrogen production and demand volumes over lifetime of the hub (mtpd)

While the current projects indicate there will be an excess of demand in phase 4, our growth plan indicates that this supply will be met through a variety of end use cases, some of which are currently still undergoing discussions, under development now, or will be added as technology maturity increases. Throughout the TEA, the MACH2 hub modeled projects that offered near term success and will enable the economic feasibility and lift off of advanced and newer technology. While these projects have less certain financials currently, enabling investments in high probability new technologies will accelerate production efficiency gains and lower future LCOH of production, while increasing the potential carbon abatement in the region.

Working with Enbridge, PBF, PSEG, PGW, Chesapeake Utilities, Holtec and Messer, 11 projects were identified that provide the basis of the production for the hub. Working with mature and established companies, the MACH2 portfolio of projects encompasses a diverse set of projects. In Figure 14 below, the composition of production is detailed over the 30-year life of the hub.

Figure 14: Composition of MACH2 Production

As illustrated by Figure 14, MACH2 has a strong production presence of both green and pink hydrogen. Detailed below in pages 63-65, projects offered by PSEG and Holtec take advantage of local already operating nuclear sites. For green hydrogen, Enbridge, PBF, PGW and Chesapeake Utilities will utilize a mixture of onsite generation and renewable PPAs to achieve competitive hydrogen production over the long term. In addition to the established companies tMACH2 has partnered with, Versogen and sHYp are two innovative companies that offer cutting edge technology that promises to lower the cost of production into the future of the hub. Both projects are detailed in page 75. Varying amounts of DOE funding have been proposed for each project. The MACH2 team modeled each project individually and looked at the implications at a hub level. Through this analysis the proportion of DOE funding was optimized to deliver the highest economic potential for the overall hub and enable the success of the hub from the initial project.

<u>Technology</u>

As stated in the business plan, the MACH2 Hub will focus on the production of green hydrogen along with the pipeline, transportation, receiving and distribution infrastructure for hydrogen. As you can see in Figure 14, through the second phase, 73% of the hub's production will be from green hydrogen sources. The majority of MACH2's green hydrogen comes from PEM and

SOEC sources. The estimated LCOH across all projects in phase I & II is ~$4.62/kg H_2. From the orange hydrogen production, the estimated LCOH across this project in phase I & II is ~$2.31/ kg H_2. To match this supply, there are several partners who will be able to take up this supply with an average price of $4.50/ kg H_2. DOE funding is crucial to the economic feasibility of these projects, with a full 50% funding, this brings down the overall price by ~$1.00/kg H_2, meeting the expected price from off takers. As you can see, DOE funding is being allocated to create a dynamic market that will grow as we move into phase III and IV.

In phase 3 and 4, the cost of hydrogen will stabilize to around $3.73/kg H_2, increasing the competitiveness of hydrogen with incumbent fossil fuels. MACH2's production of green hydrogen increases by ~7% in this phase with an overall share of production of 81%. While orange hydrogen will continue to play a role in overall production, its share will steadily decrease as green and pink hydrogen ramp up by phase 2. On the demand side, the lower cost of hydrogen and ability for off takers to develop the necessary infrastructure to increase offtake will increase overall demand to 334 tons per day. This is directly enabled by the early investment of DOE funding in distribution assets and receiving infrastructure. While Monroe and SEPTA will be the initial main users, increased infrastructure in the form of additional storage and dispensing at bus DART depots, the construction of hydrogen fueled micro-grids at Hilco and, truck fuel dispensing for a class 8 and drayage trucks will create ratable demand.

Cost of capital

[redacted]

[redacted]

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[redacted]	[redacted]
[redacted]	[redacted]

[redacted]

Primary value streams

As stated in the business plan, there is very little initial activity in the ammonia and methanol production in the region. Due to this, the primary value stream for the MACH2 hub will be green hydrogen fuel, both for transportation and to replace incumbent fuels in power generation and industry. Using the DCF models, we calculated an overall LCOH for the entire 30-year period. Using different projects, a weighted average for each year was calculated. Over time, the addition of significant new production with advanced technologies will lower costs and decrease the average. While the LCOH of a single project does not change, the collective hub will become increasingly competitive over time, promoting healthy competition, and offering the ability to form a real time market as initial long-term agreements expire, and transportation infrastructure progresses to a point where supply can reasonably be procured. In Figure 15 below, the weighted average of the cost to produce hydrogen is shown over the first 10 years of the hub.

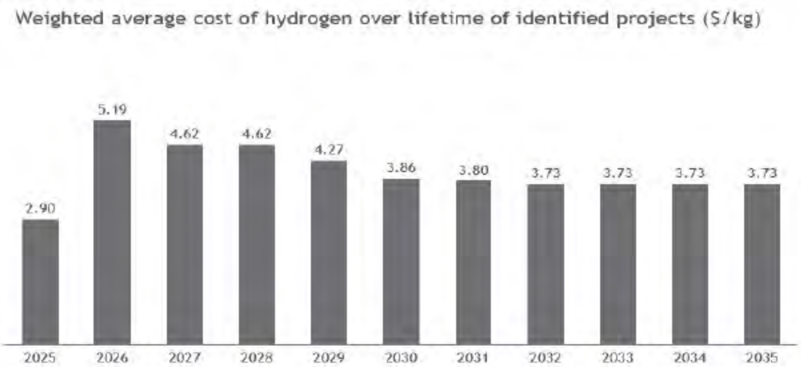

Figure 15: Weighted average cost of hydrogen production over life of the hub

Initially the production of only green and orange hydrogen lowers the overall cost of hydrogen production in the hub. As the Holtec and PSEG projects come online, the production of pink hydrogen contributes to the overall increase in the weighted average cost of hydrogen production. In later years, the addition of lower cost production from our innovative partners will decrease the overall LCOH to $3.73/kg by 2033. After consideration of the cost of production, an analysis of overall connected infrastructure required for transportation, storage and end use was undergone. Working with our project partners, sites were identified for storage, both underground and above ground. Additionally, the existing gas infrastructure, detailed in the business plan offers cost competitive refurbishment opportunities that enable the transportation of a significant amount of hydrogen. [redacted]

[redacted]

A key attribute of MACH2 is the availability of unused pipelines with permanent easements and rights of ways (ROWs) that can be refurbished for hydrogen transportation and storage. Pipeline transportation is the most efficient means to ship large quantities of hydrogen. It avoids the expense of liquefaction necessary to truck H2 in large quantities over long distances. [redacted] Each individual demand site will have its own delivery cost depending on distance from the supply source.

Co-products and Waste Streams

Each technology was evaluated separately with direct input from project partners. Waste streams for each technology were identified and costs were estimated for each stream, based off partner estimates or using the DOE H2-fast model. In addition, CO2e emissions and NOx emissions were estimated leveraging the GREET model – see LCA section. In the summary TEA/LCA spreadsheet the waste streams for each technology can be found. As stated above, co-products did not play a large role in the revenue generating potential for the hub. While the production of oxygen was identified, no analysis on potential revenue was conducted. As the hub continues to progress, these streams will be revisited to identify additional revenue potential. One exception is the projects with sHYp. The innovative start-up is using new technology detailed in pages 75 below. Their process uses seas water and generates Mg $(OH)_2$ and is profitable without the hydrogen revenue stream. As shown in the TEA the value of this co product is a substantial avenue to generate additional revenue and ensure the sHYp project is a success. As the project matures through each phase, the potential to expand the footprint of sHYp projects will be reevaluated to ensure the MACH2 hub takes full advantage of this profitable co-product.

Production projects

Overview

This section will introduce each project individually with references to assumptions and values that were used for the TEA and LCA analysis. For each project, an overview of the site layout, technology selected, cost estimations, and revenue assumptions will be given. When information for certain assumptions was not given by individual project partners, the following assumptions for each technology was used:

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Holtec Oyster Creek project

Description: The Oyster Creek's Hydrogen Generation Project (OCHGP) is designed to showcase the use of a new generation pressurized water reactor linked to an electro hydrolysis unit to produce Hydrogen. The manufactured Hydrogen will either move by truck to a nearby end user such as New Jersey Transit or a TBN south Jersey glass manufacturer or potentially be used as a combustion fuel in a nearby facility to offset natural gas use in a mixed natural gas plus Hydrogen fuel. The Oyster Creek site is a recently shut down nuclear plant. The plant is located on an 800-acre site adjacent to Oyster Creek in Lacey Township, NJ. The Oyster Creek plant and site is now owned by Holtec International as part of a decommissioning portfolio. The replacement for the previously operated reactor is the SMR-160, a 160 Mwe (net) pressurized water reactor under development and licensing by Holtec International. The plan is to conduct

Hydrogen generation by electrical separation. The Holtec Oyster Creek site will serve as the location for the hydrogen production hub, with electrical output from the SMR-160 or the near shore wind farm that will be connected to the Oyster Creek switchyard. Other renewables such as solar could also be accommodated to take excess electrical energy and transform into H2 that can be utilized in off peak scenarios.

The project makes use of existing infrastructure and technologies for hydrogen production and distribution. The commercial technologies are the Hydrogen hydrolysis unit to be selected based upon best available technology as the project unfolds. There are several potential technology choices that can operate at industrial scale efficiencies, two of which are described below as examples:

- Medium Temperature using Solid Oxide Electrolyzer Cell (SOEC)
- High Temperature Steam Electrolysis using Solid Oxide cells (HTSE)

These H_2 generation options reflect mature readily available commercial products. There are several commercial entities that build competitive units, thus there is little in the way of technology risk associated with this project. The feedstock for the hydrolysis process selected will be demineralized pure water which is readily available at the subject nuclear plant since that water is used continuously for plant makeup, thus the cost per gallon is a low as reasonably achievable. The implementation of hydrogen production at an operating nuclear plant takes advantage of an already existing staff for monitoring, oversight, and maintenance. While the H_2 production system may require a dedicated on-shift operator, the remaining personnel infrastructure is present and covered by the operating expenses of the running nuclear plant. Infrastructure systems such as fire protection, compressed air, plant control and communications are easily run to include the new facilities if they are permitted to be relatively adjacent. But in any event, all the control and indications come into the central control room for the SMR-160 and is manned on a 7x24 basis.

Performance Projections

Table 23 provides a notional spreadsheet illustrating the output of Hydrogen per day assuming 30 MWe diverted to Hydrogen generation. Diversion of higher amounts will yield more Hydrogen subject to the limits of the electrolyzers modules. In essence, we will determine optimal module size from the footprint and H_2 ton per day and then assess how man modules to host to meet a given demand.

Table 23: Holtec Oyster Creek Performance Projections

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[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	
[redacted]	[redacted]	tonne H2 per day @ Faraday efficiency factor
[redacted]	[redacted]	tonne H2 per day
[redacted]	[redacted]	Kg of H2 per day
[redacted]	[redacted]	

<u>Holtec Salem-Hope Creek Hydrogen Production</u>
Description: The Salem-Hope Creek Hydrogen Generation Project (OCHGP) is designed to showcase the use of a new generation pressurized water reactor linked to an electro hydrolysis unit to produce Hydrogen. The manufactured Hydrogen will either move by truck to an end user such as the nearby cargo container terminal at Salem, NJ or for blending into natural gas streams with South Jersey Industries to offset natural gas use in a mixed natural gas plus Hydrogen fuel. The Salem-Hope Creek complex is a site with two existing nuclear plants. The complex is located on a 740-acre site in Salem County, NJ. The Salem-Hope Creek plants are owned and operated by PSEG. The plan is to conduct Hydrogen generation by electrical separation. The Holtec Salem-Hope Creek site will serve as the location for the hydrogen production hub, with electrical output from Salem-Hope Creek complex generated on-site. The project makes use of existing infrastructure and technologies for hydrogen production and distribution. The commercial technologies are the Hydrogen hydrolysis unit to be selected based upon best available technology as the project unfolds.

There are several commercial entities that build competitive units, thus there is little in the way of technology risk associated with this project. The feedstock for the hydrolysis process selected will be demineralized pure water which is readily available at the subject nuclear plant since that water is used continuously for plant makeup, thus the cost per gallon is a low as reasonably achievable. Here again, the siting of Hydrogen of Hydrogen production at an operating nuclear plant takes advantage of an already existing staff for monitoring, oversight, and maintenance. While the H_2 production system may require a dedicated on-shift operator, the remaining personnel infrastructure is present and covered by the operating expenses of the running nuclear plant. Infrastructure systems such as fire protection, compressed air, plant control and communications are easily run to include the new facilities if they are permitted to be relatively adjacent. In any event, all the control and indications come into the central control room for the Salem-Hope Creek plants.

Performance Projections
Table 24 provides a notional spreadsheet illustrating output of Hydrogen per day assuming 30 e diverted to Hydrogen generation. Diversion of higher amounts will yield more Hydrogen subject

to the limits of the electrolyzers modules. We will determine optimal module size from the footprint and H_2 ton per day and then assess how many modules to host to meet a given demand.

Table 24: Salem Hope Creek process parameters

[redacted]	[redacted]	
	[redacted]	
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[redacted]	[redacted]	
[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	
[redacted]	[redacted]	tonne H2 per day @ Faraday efficiency factor
[redacted]	[redacted]	tonne H2 per day
[redacted]	[redacted]	Kg of H2 per day
[redacted]	[redacted]	

<u>Enbridge – Electrolysis</u>

Description: Spectra Energy Transmission II, LLC wholly owned by Enbridge, ("Enbridge") proposes a 60 MW hydrogen production facility, the "Project', to be located at a former jet fuel terminal in Paulsboro, NJ which has access to the IRPL pipeline. Enbridge is developing an MOU with the property owner at Paulsboro and their control of the site is imminent. Once fully operational, the Project will produce 16,000 kg/d of green hydrogen, eliminating 42,500 tons of CO2 emissions each year. The Project will use emissions-free power via virtual Power Purchase Agreements (PPAs) within the Pennsylvania, New Jersey, and Maryland, PJM ISO region, converting the renewable energy to hydrogen through Polymer Electrolyte Membrane (PEM) electrolyzes. Enbridge hydrogen production at Paulsboro will be shipped through the IRPL pipeline for use at by Hilco, Septa or the Monroe Refinery in Trainer, Pa.

Performance projections

Enbridge has procured engineering services from New Energy Development Company (NEDC) to support front end engineering and design for the Project. The Project design basis is summarized in Table 25 and the following Section 2 components. As illustrated, the Project will produce 16,000 kg/d once fully operational and can be online as early as Q1 2027. Production and energy usage is based on utilizing a combination of wind and solar renewable energy.

[redacted]

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[redacted]	[redacted]
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[redacted]	[redacted]
[redacted]	[redacted]
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[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

The Project design basis is developed based on the following assumptions:

- A combination of wind, solar, and possibly nuclear energy will be purchased through virtual PPAs from renewable power generation facilities located in the PJM ISO region. The power will be purchased, along with the associated RECs, for a market price between $40-$60 per MWh.
- Because emissions free energy will be supplying the Project and used to produce hydrogen, the lifecycle carbon intensity will be <0.45 kg of CO2e per 1 kg of hydrogen produced, qualifying the facility for 100% of the Production Tax Credit (PTC) under Section 45(v) of the Inflation Reductions Act (IRA).
- With a combination of wind and solar power input, the Project's availability is projected to be 65% annually. This means an average production of 16,000 kg/day of hydrogen. If additional nuclear energy can be procured, this will increase the capacity factor and production of the electrolyzers.
- Water source and wastewater discharge will depend on the site location. Given that both locations under evaluation are currently industrial, the Project assumes there is existing water and wastewater infrastructure.
- The Project in service date assumes a Full Investment Decision (FID) in Q4 2024, in line with DOE hub funding timelines, to allow for procurement of long lead-time modules.
- If the Project can procure low or zero-carbon nuclear energy, it will increase the capacity factor, the three-electrolyzer train can then operate up to 360 days each year (98% capacity factor). This would increase production to 24,000 kg H_2 per day.

Figure 17 below shows the proposed electrolysis process flow diagram. The Project design basis and cost estimates are based on steps outlined in the process flow diagram.

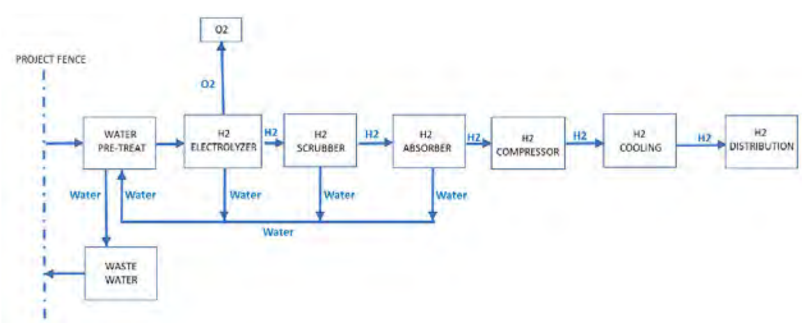

Figure 17: Project Process Flow Diagram

Site Description: The Project is proposed to be located on a 7-acre property located east of the PBF Paulsboro Refinery in Paulsboro, New Jersey. The site, a former jet fuel tank farm, is well located, adjacent to the IRPL line. The IRPL pipeline consists of several small diameter pipelines, of which, at least one (1) has previously transported hydrogen. The IRPL pipeline will be replaced with a larger capacity updated hydrogen suitable pipeline which may be either steel composition or Smartpipe. The Paulsboro site is no longer in operation, this is an excellent example of how existing fossil fuel facilities can be refigured for the hydrogen market. The proposed Project location, being a former industrial site, is located near Environmental Justice target communities that can benefit from the job opportunities generated by the project, as well as benefit from expected CO_2 emissions reductions.

Cost Estimate & Narrative

Capital Cost: [redacted]

Table 26: Preliminary Hydrogen Price Based on Assumptions

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

**PTC credit available in IRA section 45(v). For the following three scenarios of DOE capital funding (50%, 25%, and 0%), the expected hydrogen price ranges are shown.*

PSEG

Project Summary: PSEG is proposing two projects, the first of which is to construct a hydrogen production facility with an initial daily production capacity of 25 metric tons for use by end users within the MACH2 Hub region. The first PSEG production facility location will likely be the Fortress terminal in Rapauno, NJ which can be tied into the IRPL pipelines to supply Hilco's large demand or other end users within the region. In addition to evacuation by pipeline, the available acreage at Rapauno enables hydrogen truck loading racks to be built for delivery to users not connected or near to the IRPL destinations. Additionally, PSEG is proposing to construct a hydrogen vehicle fueling station at a shipping port within the hub, such as the Port of Philadelphia or the Port of Wilmington. Targeted customers are drayage fleets or port ground equipment such as yard trucks that use hydrogen as a fuel. Hydrogen for the fueling station will be produced at a co-located production plant. Initial vehicle daily volume will be 400 trucks with scaling to over 600 trucks. Longer term, the production facility could be used to produce hydrogen for large vessels, tugs, and pilot boats. As the ports work to reduce their carbon footprint, hydrogen fueled vehicles are a reasonable first step in achieving long term carbon goals. PSEG is evaluating different options for power supply to the production sites including behind-the-meter connections to the Salem and/or Hope Creek nuclear power plants or entering into PPAs with other clean energy sources to in order to maximize available PTCs. The plants will have a modular design, and thus will be scalable to demand, and will consider compression and storage, transportation, liquefaction, power and water sources, and local environmental and social considerations. The company is currently evaluating electrolyzer technologies, developing site layout and equipment requirements, identifying production sites, meeting with potential off-takers and project partners, and conducting financial analysis. Hydrogen pricing for customers is expected to be competitive with current commercial pricing considering production tax credits (PTCs) available through the Inflation Reduction Act of 2022.

Site Selection: PSEG is in the process of identifying potential production sites in southern New Jersey, Northern Delaware and Southeastern Pennsylvania. While this process is ongoing, the below sites have been identified as suitable matches for a production facility, taking into consideration regional resources including access to major highways, pipelines, and supply chains, as well as environmental remediation and permitting requirements.

Artificial Island, Salem County, NJ. This area contains the PSEG owned Hope Creek and Salem nuclear power plants as well as the NJ Wind Port being developed by the NJ Economic Development Agency (NJ EDA). Further evaluation is being performed on available acreage, nuclear safety, and development in and around coastal wetlands. PSEG is in the process of developing a scope of work for a feasibility study to be performed by an experienced engineering firm specializing in the nuclear industry and project development.

Rapauno Port & Rail Terminal, Gibbstown, NJ. This site is owned by FTAI Infrastructure Inc. (NASDAQ: FIP) following a spin-off from Fortress Transportation and Infrastructure Investors LLC (NASDAQ: FTAI) on August 1, 2022. It is strategically located on the Delaware River, providing easy access to domestic and international product markets, and being connected by all modes of transport: rail, marine and highway. Its proximity to the IRPL makes a connection via pipeline easy and convenient, [redacted]

Academy Avenue, Deptford NJ (Eagle Point). This site is a partially dismantled refinery, with some oil tanks on site still in use. It is a large industrial area with existing infrastructure that includes roads, concrete foundations, a water treatment plant, and docks. The site has good proximity to hub-identified pipelines. The current owner is not interested in selling the land but has indicated it would be willing to lease it to a developer.

6300 Philadelphia Pike, Claymont, DE. This former General Chemical site is now owned by developers D2 who have capped the property and are looking for buyers. The site consists of 44 acres, of which 2-3 acres are of environmental concern. The site has ample power and water supply and is in proximity to the IRPL pipeline which provides access to hydrogen end users along the proposed pipeline route from Trainer, Pa to Philadelphia. An active railyard on the property is not included in the sale of the property.

[redacted]

Feedstock: The two main components needed to produce hydrogen are water and power. The water source will depend on resources available at the selected production site location but is presumed to be either a local municipal water system or well water. Designs of the plant will include equipment to process the raw water to the required specifications of the electrolyzer equipment. Power for the production plant will have two potential sources depending on site location. If the plant is near the Salem and Hope Creek nuclear plants, a dedicated high voltage power line could be constructed between the power plants and the hydrogen production facility. A small switchyard at the hydrogen facility would contain the required breakers, busbars, transformers, and switchgear needed to transmit and condition the power required by the plant. If a dedicated power line from the nuclear plants is not feasible, as is the case with the fueling stations at the ports, an interconnection to the closest high voltage power source will be constructed. This often involves tying into an existing utility sub-station or by constructing a new sub-station at the point of interconnection. Similar to the concept of a dedicated transmission line from nuclear, the financial analysis assumes that a small substation at the hydrogen production facility will be constructed to receive and condition the power needed by the plant.

Offtake Agreements: PSEG has had initial discussions with Monroe, Hilco and container terminal operating companies regarding hydrogen volume needs and timing on the first deliveries. PSEG will continue to identify and contact potential off takers, including local airports for ground equipment, trucking terminals, and ports for vessel fuels. Product costs and contractual agreements will be determined after further project scoping and negotiations with the end users.

PGW

As described further below, PGW intends to facilitate the development of local hydrogen production in Philadelphia, for local distribution and end-uses in order to reduce local emissions. Carbon intensity of production and affordability are PGW's two primary evaluation criteria in selecting hydrogen technologies. Our approach is based on an unbiased, objective evaluation of the most practical and effective manner for reducing emissions today while also developing these nascent markets for long-term growth.

Based on that evaluation, PGW is pursuing an "all of the above" two-phased strategy, including the development of two hydrogen production facilities utilizing a mix of technologies to best address affordability and environmental impacts, including: Steam Methane Reforming

("SMR") utilizing Renewable Natural Gas ("RNG") feedstock and carbon capture, followed by a larger electrolyzer facility utilizing renewable electricity.

PGW also intends to support the overall MACH2 hub's development and carbon reduction goals by utilizing pipeline distribution. To this end, PGW will facilitate development of new dedicated hydrogen pipelines from (1) the proposed PGW production facility at Richmond to nearby end-uses at the Tioga Marine Terminal run by the Delaware River Stevedores (DRS) and, (2) the regional Inter-Refinery Pipeline's (IRPL) will be extended by approximately 1 mile from its current terminus at Hilco to supply PGW's Passyunk Avenue gaseous truck loading terminal for initial supply to SEPTA and the Philadelphia Municipal fleet. As hydrogen demand increases, and on-site production is economically justified at the Passyunk site, PGW will construct hydrogen production there using electrolyzers with renewable power. This approach provides early initial demand for the Enbridge or PSEG production sites along the IRPL, giving them a greater probability of success, subsequently introducing more production at Passyunk when warranted, reducing investment risk while growing MACH2 supply. It should also be noted that as the IRPL will be operated as an open stock system, the PGW hydrogen production at Passyunk can also supply Hilco, Monroe or any other user along the IRPL.

Site selection

Phase 1: Based on current technologies, utilities, and costs, PGW is proposing to facilitate a Phase I project at its Richmond plant, utilizing the more mature and cost competitive SMR process. PGW is planning on utilizing Renewable Natural Gas ("RNG") feedstock to mitigate the project's full lifecycle emissions and qualify for the maximum hydrogen Production Tax Credit based on emissions. Furthermore, PGW is also including carbon capture technology in the proposed Phase I project, with the assumption that offtake markets will be developed by that time. Based on our analysis, this proposed Phase I SMR approach is both the most affordable (in terms of hydrogen price-point) and sustainable (in terms of full life cycle carbon intensity) of the options practically available to us today. For now, the proposed Phase I SMR approach incorporating RNG feedstock and carbon capture technology provides a cost-effective Phase I solution while still mitigating CO2 emissions.

We acknowledge the rapidly evolving technologies and overall industry, and are intentionally building in flexibility, allowing future pivots as better options for further reducing carbon intensity become practically feasible and cost competitive. As described further below, PGW will continue refining its analyses and proposed project between this DOE CleanH2 Hubs submission and the expected award notifications. If alternate Phase I approaches, specifically electrolysis utilizing renewable power, are feasible and better address the carbon intensity and affordability evaluation criteria, then PGW will modify its Phase I approach. Regardless, PGW will increasingly mitigate project emissions going forward into Phase II as technologies and markets continue developing. The Phase I project is currently planned as a 7.5 tons per day ("tpd") SMR production facility at PGW's Richmond Plant, selected and sized to match full-scale demand of targeted nearby end-users, Tioga Marine Terminal and the Philadelphia Municipal Fleet's Area 5 location, allowing for short-distance direct distribution pipelines. This approach is intended to minimize the need for and costs of longer-distance distribution, and maximize PGW current assets of existing real estate, energy infrastructure experience, and rights-of-way within the City of Philadelphia.

Phase II: PGW intends to pursue a Phase II project to facilitate additional hydrogen production capacity as new end-use loads come on-line and scale. As of now, Phase II would be an electrolyzer production facility utilizing renewable electricity, based on the expectation that new large-scale renewable power will be more readily available several years in the future. Again, these expectations will be revisited closer to project decision-points, through the same lens as the Phase I evaluation: prioritizing the best practically feasible balance of both affordability and environmental impacts. The Phase II project is currently planned as a 15 tpd electrolyzer production facility at PGW's Passyunk Plant. PGW selected this site due to its proximity to other large transportation fleets, including the SEPTA Southern Depot and potential future nearby end-use applications. Phase II therefore would also include the construction of additional dedicated hydrogen distribution pipelines from the PGW production facilities to additional nearby hydrogen end-users as new load continues to scale.

End use cases

Phase I: Initially in Phase 1, PGW is prioritizing mobility end-uses, including heavy duty, long-range vehicle fleets and ground support vehicles. In this phase, production levels of 4.5 tons/day are being targeted at the Richmond Plant and is estimated to fuel 130 vehicles per day. The PGW Passyunk Ave. site will initially take in supply off the IRPL from Enbridge and/or PSEG for pressurized truck loading and when economically justified, develop additional green production at that site during a Phase II build out.

Phase II: PGW also envisions providing hydrogen for facility power and heating applications, including logistics hubs and/or back-up power and resiliency for critical buildings and infrastructure. Future phases would also include an expansion of transportation applications. By the end of a potential Phase II, PGW envisions scaling to approximately 15 tons per day (tpd) in production at both plants, for 30 tpd production total. Sections 2-4 are based on the requirements per site for each phase, looking at only 4.5 tpd (Phase I) or 15 tpd (Phase II) production totals. Total project costs and utility usage would double when considering comparable implementation at both sites.

Production Performance:

Several different production scenarios were looked at by PGW. The two included in the TEA are the following:

- PGW SMR with renewable natural gas and carbon capture for Phase I
- PGW Electrolysis using renewable electricity for Phase II

Table 27: SMR CAPEX and OPEX assumptions

	SMR w/ RNG + Carbon Capture	Electrolysis
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Site layout
Passyunk: The Passyunk site has a large plot of land in the northwest corner of the site that is available for development. For the purposes of this document, system footprints are overlaid over the site to indicate approximate scale but are not necessarily where equipment will end up being installed and local codes may impact spacing requirements. Grid regions are overlaid to correlate to PGW's drawings for reference. Each scenario includes production area, compression area, storage (marked 'S'), a small 10' x 10' building for switchgear (can be hard to see, labeled 'PS'), and a large lot with 4 (4.5 tpd) or 8 (15 tpd) refueling / truck loading stations. There are no space constraints for electrolyzers in this area, even at the 15 tons per day case.

Richmond: The Richmond site a couple of undeveloped plots of land in the south portion of the site, labeled Zone-1 and Zone-2 here for reference. Like with Passyunk, system footprints are overlaid over the site to indicate approximate scale but are not necessarily where equipment will end up being installed and local codes may impact spacing requirements. Each scenario includes production area, compression area, storage (marked 'S'), a small 10' x 10' building for switchgear (can be hard to see, labeled 'PS'), and a large lot with 4 (4.5 tpd) or 8 (15 tpd) refueling / truck loading stations.

PBF
Overall Scope and Objectives of the PBF H2 Hub: PBF is evaluating a comprehensive Delaware City Clean Hydrogen Hub concept (DCH2) that would be built on 2,500 acres of vacant land in New Castle County, DE, owned by DCRC. The scope and scale of the potential DCH2 project includes (i) generating 350 MW of renewable electricity primarily from solar power and potentially wind and hydropower; (ii) desalination and deionization of brackish water already withdrawn from the Delaware River; (iii) production of 50,000 mt/year (137 mt/d) of clean hydrogen via electrolysis; (iv) the development of 10 million square feet of distribution warehouse space, offices and labs; (v) hydrogen compression, storage, and vehicle/transportation loading facilities.

PBF particularly envisions the clean hydrogen it produces in DCH2 to be used for transportation, both in fuel cells and in hydrogen internal combustion engines. The base scope of the DCH2 project anticipates utilizing hydrogen to fuel a 12,500 medium-duty truck fleet supporting the distribution warehouses, as well as in-warehouse forklifts and equipment at the Delaware City site, displacing 150,000 gallons per day of diesel fuel. To support other hydrogen end-users in the region, PBF envisions building a 12-inch hydrogen pipeline, capable of carrying 63 MMSCFD (150 mt/d) from DCH2 to the greater Philadelphia area to support transportation, power generation, industrial and commercial uses of clean hydrogen. For the initial phase, or phase 1, of the project PBF is looking at starting with generating 76,000 kg per day of hydrogen via electrolysis using PEM electrolyzers. This will be transported via trucks. As the production scales in later phases the project will scale with it, with the intention of producing the amount mentioned above. Once the amount of production reaches the needed scale the construction of the pipeline will commence.

Site Selection: PBF's subsidiaries own and control all real property required for the DCH2, Paulsboro and Delaware City projects. DCRC owns 2,500 acres of undeveloped land surrounding its Delaware City Refinery, one of four operating petroleum refineries on the U.S. East Coast. In addition to the property, which is primarily leased to farmers, DCRC has a well-trained, experienced workforce that could be leveraged to operate and maintain hydrogen production facilities and supporting equipment if the project is approved, financed, and built.

The DCRC property is situated 20-miles south of Wilmington, DE between the Delaware River and U.S. Route 1. Importantly, the Delaware River, which is brackish in this area, and/or private purveyors could provide a steady, year-round supply of water for electrolyzing into hydrogen. The site is ideally positioned for facilitating distribution of goods, providing direct access to the interstate highway system via the I-95 corridor, with the New York City, Philadelphia, Baltimore, and Washington, DC metropolitan areas all within two-hour drives. Nearby railroads, ports, and airports provide additional transportation options and potential hydrogen customers.

Feedstocks: The feedstock to the DCH2 electrolyzers will be brackish water from the DCRC once-through cooling system, drawn prior to returning to the river. No new water is currently expected to be drawn from the Delaware River. No fresh water is expected to be utilized for the DCH2 project. To supply feedstock electricity, PBF is evaluating REC-based electricity supplies and power purchase agreements in addition to onsite generation of renewable electricity.

Model assumptions: Table 28 shows the assumptions used to conduct the analysis in the TEA:

Table 28 – PBF Electrolysis model assumptions

[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

Table 29 – PBF LCOH

	LCOH [redacted]
[redacted]	[redacted]

Messer

Messer is currently in discussion with several landowners to identify a suitable location for their site as well as power suppliers for renewable or nuclear power supply. They are considering an existing trash to steam plant and other properties such as the D2 site, proximate to the IRPL as a site for construction and operation of 28 tons of hydrogen production per day.

Table 30 – Messer Electrolysis model assumptions

Input	Messer Delaware Valley
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted])

Using these estimates the following levelized cost of hydrogen is shown:

Table 31 – Messer LCOH

	LCOH ($/kg)
[redacted]	[redacted]

Chesapeake Utilities

Chesapeake utilities is constructing a PEM electrolysis site in southern Delaware on an already owned site. Current project estimates have production of 7 tons per day. Chesapeake aims to supply this hydrogen to nearby demand partners and a company owned site Safety Town. Safety Town will use hydrogen for power and help advance hydrogen handling and distribution knowledge. Additionally, the hub will leverage Safety Town to ensure all project partners have access to safety training and expertise in the production. Chesapeake will use truck transportation to move hydrogen from the production site to end users. Below in Table 32 are the values used to calculate the LCOH of production:

Table 32 – Chesapeake Electrolysis model assumptions

[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

Using these estimates the following levelized cost of hydrogen is shown:

Table 33 - Chesapeake LCOH

	LCOH ($/kg)
[redacted]	[redacted]

<u>Versogen and sHYp</u>

The MACH2 hub has identified two promising companies with less mature technology that will power the future of the hub and provide lower cost production through the use of more efficient production technology with Versogen and innovative co-products that will improve the overall economics of hydrogen production. Both of these projects are commercializing their products with both projecting that they will reach TRL 8 within the required timeframe.

Both projects will be built over the course of several phases. The two projects will not be included in their initial phases as they begin to commercialize. Once they reach commercial scale the hub will then consider them for funding. Using current projections both projects will be commercial by the end of Phase 3 with a ramp-up of production over a three-year time-period. Additionally, for both projects it is assumed that the PTC will only be available for 10 years from the start of the project. In phase 4 for sHYp (2030) this means that there are only 4 years left of the PTC and that is what was modeled for the GAAP analysis.

<u>sHYp:</u>

As described above sHYp is a technology that uses sea water to produce hydrogen and Mg (OH)2. They will need to be located by brackish water and are actively talking with multiple ports and others including the Port of Wilmington and the Chemours Chambers Works plant on the Delaware River in southern New Jersey. The salinity of the water supply and the ability to handle bulk solid material are considerations for the siting of the sHYp production site. In Table 34 below the assumptions used to model the sHYp projects are shown. Phases 1-3 are shown for informational purposes only and were not included in the analysis, only phases after 4 were included in cost and revenue projections.

Table 34: sHYp model assumptions

Input	Phase 1	Phase 2	Phase 3	Phase 4
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]	[redacted]			
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]			
[redacted]	[redacted]			
[redacted]	[redacted]			
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]			
[redacted]	[redacted]			

Table 35: LCOH of hydrogen by Phase IV

	LCOH ($/kg)	Revenue from Mg (OH)2 ($/kg H2)
[redacted]	[redacted]	[redacted]

Versogen:

As described in the project partner section Versogen is using innovative AEM technology to produce low-cost hydrogen at scale. They are in conversations with several partners to locate a suitable site with pipeline connectivity for their production. Similar to sHYp they will be ramping up production in phases throughout the life of the hub. In Table 36 below the assumptions used to model the Versogen projects are shown. Phases 1-3 are shown for informational purposes only and were not included in the analysis, only phases after 4 were included in cost and revenue projections.

Table 36: Versogen project assumptions

	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]					
[redacted]	[redacted]					
[redacted]	[redacted]					
[redacted]	[redacted]					
[redacted]	[redacted]					
[redacted]	[redacted]					
[redacted]	[redacted]					
[redacted]	[redacted]					
[redacted]	[redacted]					

End use projects

As discussed in the business plan, the end use cases for the MACH2 hub revolve around 4 main use cases currently. Below is a table detailing the information used for the TEA:

Table 37: Overview of MACH2 end-use projects

Partner	Year demand starts	Category	Max. demand (tpd)	CAPEX ($M)
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

As described in the sections above and shown in the business plan section, the MACH2 demand is initially focused on transportation use cases and boiler fuel. Throughout the first phase Monroe's demand for hydrogen to incorporate into their boiler fuel will enable the initial phases of production. As the hub enters phase 2 and 3 a large demand center supported by the power, steam production and truck refueling infrastructure detailed below will emerge at the Hilco facility which is planning on using hydrogen fuel for a microgrid.

While final prices are subject to negotiation between parties, the expected cost of hydrogen production, transportation and storage will meet cost targets set by target end users as demonstrated in the letters of commitment that accompany this application. [redacted]. As negotiations between parties continue to develop these estimates will be revised to get a more accurate cost of delivery depending on use case, delivery location and delivery method. [redacted] This is a more conservative estimate that portrays a perfect market. As partners continue discussions and finalize contracts the overall return will more accurately reflect the true return from the sales of hydrogen at contracted prices ultimately raising the overall rate of return.

Transportation & storage projects

Hydrogen Transportation projects (pipelines)

MACH2 plans for its core H_2 transportation to take place through a 50-mile "open stock"[23] pipeline network connecting multiple producers with end users and supplemented with truck delivery to supply users located away from the pipelines, for industrial, power generation and transportation applications. MACH2 is populated with several companies having extensive pipeline construction and operations experience, including, Enbridge, PGW, Buckeye, PECO, Fortress, and PSEG. Given the extent of existing infrastructure and permanent easements

[23] An "Open Stock" pipeline system allows multiple producers to inject into, and multiple receivers to take supply from a pipeline simultaneously, like natural gas distribution. Inventory allotments to producers and end users are monitored by the pipeline operator to balance the system, ensuring that offtakers are only allowed to take deliveries of quantities they have purchased. Producers are, in turn, required to supply their commitments, ensuring their supply has an offtaker.

already controlled by Hub participants, MACH2 holds a significant competitive advantage. In addition to the primary pipeline system smaller pipeline projects of less than 2 miles may also be constructed to optimize distribution. This means that, to complement existing ROWs, there are short segments of ROW through industrialized areas that will need to be acquired. However, as they are not in residential areas and we have identified easement owners who are industrial companies and not private citizens, we are confident of the feasibility of acquiring additional ROWs without significant resistance posing a risk to the project. MACH2 currently has four key proposed pipeline projects with a total length of ~44 miles, estimated CapEx of $280M and a daily capacity of 355 mt of H_2; these are summarized in Figure 18, with the two major pipeline projects planned for development in MACH2 being:

1) Laying a new 24-mile line in existing ROW between PBF Del City to Twin Oaks. This project, together with a 5-mile pipeline from Twin Oaks to Marcus Hook, PA, mentioned below, will connect the entire north-south axis of MACH2.
2) The removal and replacement of the Inter Refinery Pipeline (IRPL) between Marcus Hook and Hilco Bellwether (~24 miles)

Pipeline capacity on the 48 miles of the main pipeline in MACH2 (from Delaware City to Philadelphia) will be increased in phases and the most economic operationally feasible plan will be developed to ensure economic increases to future capacity is available. The replacement of this pipeline will require permitting from the Army Corp of Engineers (ACE) as there are river crossings of the Delaware River. ACE permitting may take 36 months and construction of the lines is estimated to require 12 months. In addition to these two key projects, the below short-distance pipelines have been proposed or are being considered to efficiently improve pipeline connectivity across producers and end-users of the hub:

1) *(Proposed, with Class 4 estimates included in TEA)* A 1.5 to 2-mile extension of the IRPL to supply PGW truck loading at Passyunk to enable supply to SEPTA and municipal fleets; after PGW builds additional production in Phase 2 at Passyunk this pipeline can deliver H2 to Hilco and other outlets along the IRPL.
2) *(Proposed, with Class 4 estimates included in TEA)* One mile connection from the IRPL at Marcus Hook to Monroe Refining in Trainer, PA. enabling Enbridge, PBF, PSEG & PGW production to supply Monroe.
3) A 5-mile pipeline from Twin Oaks, PA to Marcus Hook, PA developed by PBF to bring their Delaware City production into the northern section of the Hub, giving them access to the end-use in the PA area.
4) A 1-mile IRPL extension between Monroe, Trainer, PA, to the trash-to-steam plant in Chester, PA, where Messer is likely to establish production. This will give Messer access to Monroe, Hilco and Septa demand.
5) An approximately 2-mile section connecting Marcus Hook to the Fortress - Rapauno Terminal in Gibbstown, NJ, which will likely be the production site for one of the PSEG projects.
6) 1 mile section of pipeline from PGW Richmond to the Tioga Terminal (DRS).

These short distance connecting pipelines would add an additional 8-9 miles of connectivity. Early estimates for pipelines 3 to 6 above (not class 4), suggest total CapEx costs for these additional pipelines could amount to $40-60M. These estimates will be refined as MACH2 further engages in conversations with different partners to optimize capital expenditures. Within these smaller pipelines, there is approximately 8 -9 miles of ROW needed to be acquired, however, since they are required in industrial areas with existing utility or industrial controlled ROW, we are not expecting difficulty in acquiring these necessary easements.

It should be noted that the IRPL transits along the perimeter of the Philadelphia International Airport (PHL). MACH2 has engaged the surface transportation providers at PHL and all regional airports to develop hydrogen fueled ground support vehicles. It is only a matter of time for aviation technology to enable hydrogen for use in aircraft and MACH2 infrastructure will be in place to serve the ground fuels and aviation requirements through pipeline and truck load deliveries of hydrogen.

The legacy of petroleum refining in MACH2 and now underutilized inter-regional pipeline connectivity (with permanent easements) available from Philadelphia provides MACH2 with excellent opportunities to connect to the NYSERDA hub in central New York and in New York Harbor which will enhance supply economics and security of supply for both NYSERDA and MACH2 hubs.

Partner Name	Projects	Project Scope	Location	Key estimates
Midstream Infra Developers	Marcus Hook Hydrogen Connector		Marcus Hook to Monroe Energy	CapEx: $4 to $6M Capacity: 50 MT/day Length in miles: 1
Midstream Infra Developers	Inter Refinery Pipeline (IRPL)		Marcus Hook to Sunoco, PA	CapEx: $158M to 160M Capacity: 150 MT/day Length in miles: 18
PBF	Delaware City - Philadelphia Hydrogen Pipeline		Delaware City to Twin Oaks	CapEx: $110M Capacity: 150 MT/day Length in miles: 23
PGW	PGW Passyunk H2 Distribution		PGW, Passyunk to SEPTA	CapEx: $4M Capacity: 4.6 MT/day Length in miles: 2

H₂ Pipeline

Figure 18: Pipeline projects with their location, cost, capacity, and length

<u>Other Hydrogen transport projects (Trucks and Loading)</u>

The core hydrogen transportation method within the MACH2 Hubs will be pipelines, however, the Hub also counts with projects involving truck delivery. In this respect, Marlin gas services, a subsidiary of Chesapeake Utilities, is looking to acquire four additional Quantum VP 5000 H trailers in addition to its existing fleet of six hydrogen trailers with a capacity of transporting 110,000 cubic feet of gaseous hydrogen. These four trailers will have a total CapEx of $3.4M and can carry approx. 5mt of H2. In addition to the above, Lee Transport Systems, a large regional common carrier of petroleum gasses and liquids, is exploring the economics and operations of both pressurized and liquified trailers and is working with PBF, PGW, SEPTA and Air Liquide to advance over the road transportation of Hydrogen.

Furthermore, while not included in this TEA analysis, PBF is also considering a Delaware City Hydrogen Storage and Loading project to support truck-loading and refueling to distribute produced hydrogen across the region. Current loading capacity amounts to 70 mt per day. The scope includes as well supporting a fleet of 12,500 distribution trucks to enable on-site logistics warehouses. PBF is additionally evaluating liquefaction, storage and loading of liquid hydrogen onto refrigerated rail cars for distribution, leveraging the sites extensive rail infrastructure. some potential partners are exploring the costs of a pressurized H_2 truck loading facility. Initial estimates by Air Liquide and MACH2 team suggest approx. costs of $2M CapEx for 1 mt per day capacity, i.e., a 25 mt per day truck loading facility would have a CapEx of $50M. The MACH2 Hub will continue to refine H_2 delivery projects after this initial submission.

H_2 storage

The main storage project for the MACH2 Hub at this time has been proposed by Enbridge, an equity stake owner of the pipeline technology company Smartpipe Technologies. Smartpipe is a high-pressure reinforced thermoplastic pipeline replacement technology. With Smartpipe's patented technology, a high-strength, composite internal pipeline liner is pulled through an existing pipeline to increase its structural integrity and allow for improved monitoring using an embedded fiber optics line that allows for instant pipeline monitoring and leak detection. Smartpipe's non-metallic construction delivers a high degree of improved safety and reliability, with engineered safety factors, namely twice those of new standard steel pipelines. In addition to improving safety, Smartpipe's technology can support hydrogen and carbon dioxide energy infrastructure needed in the energy transition. Due to the technology's trenchless installation method, an important application will likely be in upgrading existing aging steel pipelines currently in use, particularly in hard to access locations where excavation activities may be disruptive to landowners or the surrounding community. Smartpipe is working to obtain certification for storage and transportation of hydrogen by January 2024. The following table shows hydrogen storage capacity inside each mile of Smartpipe, categorized by sizing of the host pipe. In addition to SmartPipe, PBF Delaware City H_2 Storage and Loading will have 7 mt storage capacity.

Table 38: Potential crude oil pipelines to be retrofitted as SmartPipe for storage.

Existing Pipeline	Length (miles)	Outer Diameter (inches)	SmartPipe Diameter (inches)	Storage (kg/Mile)	Estimated Capacity (mt of H2)
FMT to PHL Crude	8.28	24	23.25	1,944.00	16
Buckeye Eagle Pt. - Booth,PA	15	24	23.25	1,944.00	29

[redacted]

From a technology perspective, SmartPipe expects to be hydrogen ready in Q1 2024. The pipe has been tested by the Department of Energy (DOE) and found to be compliant with DOE's composite pipe standards. There will be testing of a new pipe wrap material in 2023 to verify the expected reduction of hydrogen permeability. SmartPipe is conducting studies on pressure cycling to verify pipe durability. So far, the pipe performed well after >40,000 pressurize-depressurize cycles. While the regulatory landscape for hydrogen use is currently unclear, SmartPipe assumes a special permit required under PHMSA would take 2-3 years to complete.

The MACH2 Hub team has identified potential opportunities for retrofitting 23 miles of crude oil pipelines with SmartPipe technology and leverage them for storage. This would provide a storage capacity of 45 mt of H2 at any given moment which represents 17% of daily production in 2032. Should SmartPipe secure final approval by PHMSA, it will provide a means for MACH2 to re-utilize existing pipelines and ROWs for additional connectivity and enabling infrastructure within MACH2 and connections to NYSERDA and the other Pennsylvania Hub. In addition to this, the MACH2 Hub is exploring additional opportunities for above-ground pressurized storage. Initial estimates from partners seem to indicate a CapEx need of approximately $1M for 1MT of H2 storage. Once further developed, this option may present financial advantages in front of the SmartPipe, being more economically viable.

Other Incentives Availability: As indicated on the business plan section, the MACH2 region itself has a very favorable legislative and policy environment for clean energy. Greater detail can be found in the Financial and Business plan.

Emissions and Resource Consumption LCA

As previously illustrated in business plan and TEA sections and reflected on tables 6 and 7 of the "H2Hub TEA & LCA projections" attachment, the MACH2 Hub will achieve market liftoff through a mix of orange, pink, and green hydrogen in phases I and II. The Hub's hydrogen production will subsequently shift heavily towards pink and green H_2, in line with the strong renewable energy and portfolio targets in MACH2 regions - as shown in Figure 19.

As described on the business plan, electricity feedstock for pink H_2 in MACH2 will be ensured by a mix of direct ties to nuclear plants, with projected rates of 44-58 kWh/kg H_2. These consumption rates vary with electrolyzer efficiency. In general, the MACH2 team has assumed a 57% efficiency for PEM and 75% for SOEC electrolyzers. Possibilities for direct ties to the Salem & Hope Creek nuclear plants operated by PSEG are being analyzed and will be further studied by MACH2, PSEG and the corresponding Regional Transmission Organization (PJM). Feedstock for green H_2 is composed by a mix of renewable electricity generation and electrolysis technologies, described in the project overviews included in the TEA, and with projected average electricity consumption rates of 56 kWh/kg H_2, varying by project and technology. Overall, the Hub is currently expected to consume an average of approximately 3,755 GWh / year, with peak consumption being reached in 2032 of around 5,500 GWh / year – see Figure 19.

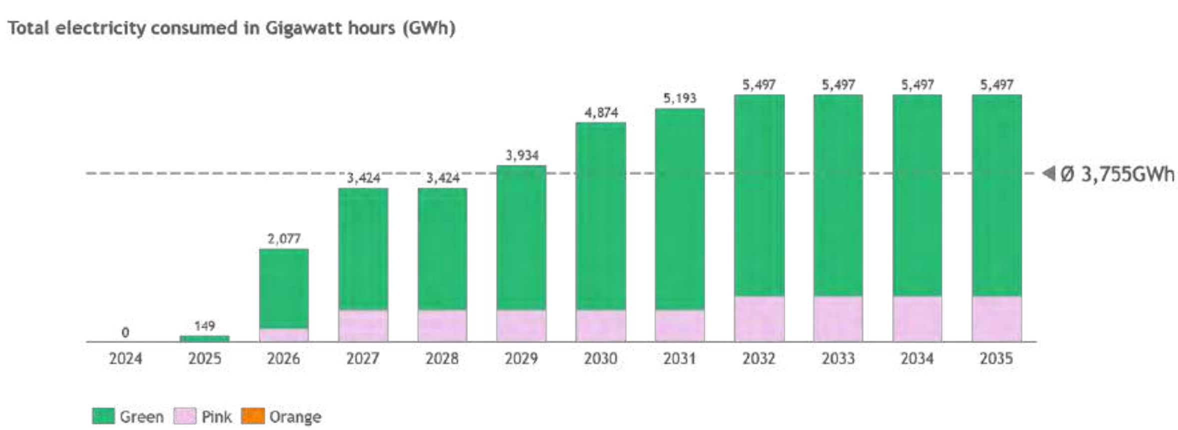

Figure 19: Evolution of projected electricity consumption for H2 production

When focusing on green hydrogen production, the total estimated electricity required in 2032 from renewables amounts to ~4,500 GWh / year. This, assuming a capacity factor of 30%, would translate approximately into 1.7 GW of installed renewable capacity as summarized in the following Table 39. The electricity demand (first row of Table *39*) is estimated based on the total production volume of green H_2 needed, the energy intensity of a kg of H_2, and the efficiency of the corresponding electrolyzers. On average, a conservative estimate of the power needed to produce 1 kg of green H_2 with a PEM electrolyzer of 57% efficiency, amounts to 58 kWh/kg H_2. The renewable energy installed capacity or nameplate capacity[24] (second row of Table 39) is calculated from the annual electricity demand and assuming a blanket generation capacity factor of 30% for simplification purposes.[25]

Table 39: Estimated Renewable Energy Demand & capacity by year for Green Hydrogen production

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Renewable Energy Demand by year (GWh)	-	149	1,770	2,709	2,709	3,219	4,159	4,478	4,478	4,478	4,478	4,478
Renewable Energy Capacity needed (GW)	-	0.1	0.7	1.0	1.0	1.2	1.6	1.7	1.7	1.7	1.7	1.7

As described, total renewable energy capacity for green H_2 production is estimated to reach a maximum of 1.7 GW in 2032 (cumulative). Given strong dependency with electrolyzer efficiency, improvements in electrolyzer efficiency in upcoming years can reduce renewable energy and capacity needs. For example, PEM electrolyzers have significant opportunities for increased electrical efficiency without sacrificing durability. Potential improvements are being analyzed in multiple academic studies and may come from multiple sources – e.g., reducing catalyst loading, integrating new membranes below 50µm[26]. As an illustrative example, an increase of average PEM electrolyzer efficiency from 57% to 70% would reduce total renewable capacity needs for the same green H_2 production from 1.7GW to 1.4GW. This number can be further reduced with improvements in renewable generation technology capacity factors.

This total renewable generation capacity of 1.7GW for green H_2 production will be secured by MACH2 partners by a mix of PPAs and renewable capacity development projects. In context, this total capacity represents around 20% of the 8.3 GW planned renewable capacity to be added between 2024 to 2030 in the PJM Regional Transmission Organization. With all the hub states pushing to reshape their economy to a lower carbon one by 2050 through their respective climate action plans[27], this figure is expected to only continue to grow, making MACH2's renewable capacity build achievable. In addition, many of the individual projects

[24] Renewable power generation capacity is measured as the maximum net generating capacity of power plants and other installations that use renewable energy sources to produce electricity.
[25] Green Hydrogen producers at MACH2 will use a mix of PPA and on-site generation from solar or wind sources. On-shore wind generation capacity factors in the region are close to 30%, with solar CFs around 20%. The blended 30% CF assumption is a conservative estimate considering the pace of technological improvements.
[26] High Efficiency PEM Water Electrolysis Enabled by Advanced Catalysts, Membranes and Processes – Energy materials network, DOE
[27] PA.gov; NJ.gov; Delaware.gov

require renewable generation capacity of less than 80MW, the federal limit to enable interconnection through Distribution lines. This can potentially represent an opportunity for MACH2 partners to work with PJM and the corresponding regional utilities to qualify as level 2 or level 3 interconnection and bypass the PJM Transmission interconnection queue to accelerate project development.

Regarding emissions, MACH2 has leveraged the GREET model to assess the carbon intensity of its operations and estimate well-to-gate emissions. As seen in Figure 20, early on, MACH2's production trend shows a decrease on well-to-gate CO2 emissions from 2024 until 2026, reaching the lowest carbon intensity of -0.44 Kg CO_{2e}/ Kg H_2. This trend is caused by Orange H_2 being produced from RNG with CCS estimated to have a negative carbon intensity of -6.5 kg CO2e/kg H_2 in the GREET model. The RNG source for SMR has been assumed to be from landfill gas, this leads to a conservative estimate of carbon intensity. For instance, the carbon intensity of other RNG sources in the GREET model for biogas from anaerobic digestion of wastewater sludge is -16.4 Kg CO_{2e}/ Kg H_2 without CCS, and -24.2 Kg CO_{2e}/ Kg H_2 with CCS. The trend described above is inverted with the increased share of green and pink H_2 in subsequent years. The hub average reaches approx. -0.17 Kg CO_{2e}/ Kg H_2 in 2028-2035, years in which the share of green H_2 in MACH2 is around 80%. MACH2's operations support transition to low carbon economy, with the weighted average LCA well-to-gate CO_{2e} intensity for the hub in 2032 sitting at approximately -0.14 Kg CO_{2e}/ Kg H_2, making it a carbon negative hub for H2 production and well below the 0.45 kg CO_{2e}/kg H_2 range needed for the full 45V PTC.

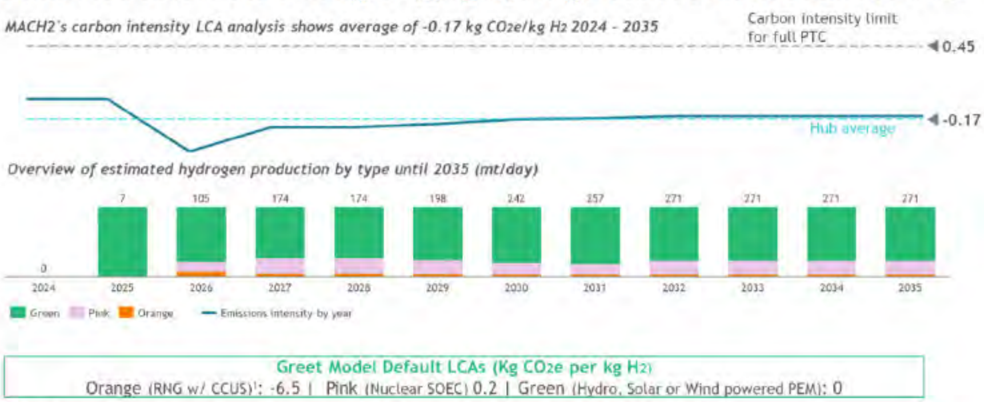

Figure 20: Evolution of projected well-to-gate CO2e emissions for MACH2 Hub

This low carbon intensity is driven by the share of orange H_2 which combined with CCS has a negative carbon intensity. As mentioned in the business plan, MACH2's orange H_2 production will be driven by SMR using renewable natural gas from PGW to achieve a more competitive production cost in early phases. Emissions from using renewable natural gas (RNG)/biogas gives a baseline carbon intensity of 0.2 kg CO2e/kg H_2, as given in the GREET model. However, PGW has included carbon capture (CCS) on their SMR w/ RNG which has further reduced the hub's emissions, given SMR w/ RNG and CCS has a carbon intensity of -6.5Kg CO_{2e}/ Kg H_2 in line with the GREET model. In the medium term, PGW is supplementing their production through a 10MW PEM electrolyzer to support MACH2's strategy of transitioning to green and pink H_2.

Table 40: Projected weighted average well-to-gate carbon intensity of MACH2 projects by production technology

MACH2 Projects projected well-to-gate carbon intensity (Kg CO_{2e}/kg H_2)

Green H_2	0
Orange H_2 (with CCS)	-6.5
Pink H_2	0.2 (SOEC) - 0.3(PEM)

To complement MACH2's strategy of targeting pink and green H_2, midstream delivery emissions will be lowered by minimizing truck H_2 delivery, leveraging existing infrastructure and rights of way to retrofit existing pipelines through partners PBF, Chesapeake utilities, and PGW. New pipelines from Monroe to Marcus Hook and Delaware City Refining company to the City of Philadelphia will be laid down in parallel with existing ones to complement the Hub's connecting infrastructure. A third-party midstream infrastructure developer[28] will lift and lay the Inter-refinery pipeline (IRPL) to make it suitable for hydrogen, connecting the Hilco Bellwether District just west of the city of Philadelphia to Marcus Hook and Twin Oaks in PA and acting as one of the core distribution veins of the Hub. As laid out in the business plan section, MACH2's layout is optimal to support short distance truck delivery of CGH_2. Additional trucking delivery projects are being assessed by MACH2 partners and truck loading can be staged at any site along the pipeline routes for most efficient last mile distribution. Moreover, potential future access to Sustainable Aviation Fuel through Monroe / Delta, or other players like United or American Airlines who have expressed early interest, give MACH2 the potential to expand to other major airports in the broader region, further contributing to the decarbonization of the aviation sector.

Since MACH2's H_2 production is mostly comprised of around 97% green and pink H2 in 2032, fresh water is an important feedstock component for the electrolyzing processes. MACH2 has leveraged the GREET model and partner surveys to estimate water consumption across the hub at ~590 million gallons per year by 2032, approximately 6 gallons / mt H_2– see Figure 21. The main sources for water feedstock in MACH2's region are the Delaware and Schuylkill rivers, respectively with an average discharge of 13,000 cf/s[8] and 4,700 cf/s[29], more than sufficient to satisfy the estimated need of MACH2 by 2032. In comparison, an inhabitant of the city of Philadelphia consumes on average 100 gallons per day of water. This means that, at the peak demand of ~590M gallons per year, the water consumption level would be equivalent to the consumption in a year by ~16,000 residents of the City of Philadelphia (1% population), a reasonable increase given water resource availability in the region.

Moreover, certain MACH2 partners are defining plans to leverage existing water streams for electrolyzer feedstock. For example, PBF will be using brackish water from the once-through cooling system at Delaware City for their electrolysis process. Finally, despite not being dependent on it, an important portion of MACH2's region is situated just south of the city of Philadelphia, a city underlined by both the unconsolidated aquifers (chiefly sand and gravel) of the Coastal Plain and the consolidated-rock aquifers (chiefly schist of the Wissahickon Formation) of the Piedmont, providing potential access to additional water resources[30].

[28] Final partner to be identified
[29] US Geological Survey (USGS), water data for last 35 years
[30] US Geological Survey (USGS), Geohydrology and ground-water resources of Philadelphia, Pennsylvania

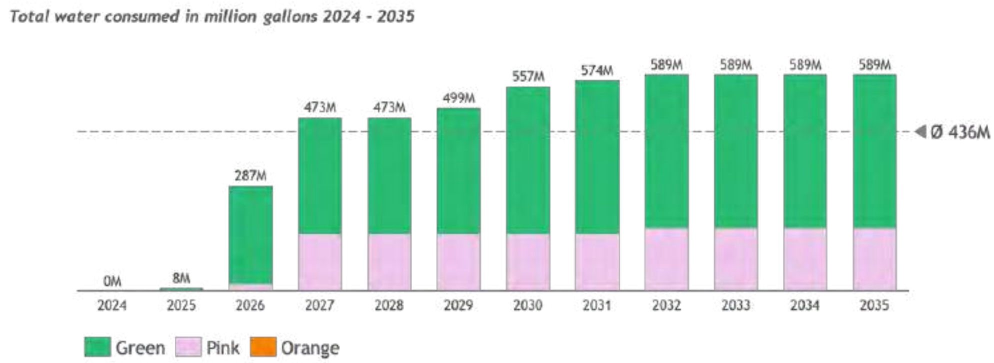

Figure 21: Evolution of projected freshwater consumption for H2 production by MACH2 Hub

Finally, for the only orange H2 production project in the Hub, total production amounts to 7,500 mtpd, or 2,738 mt per year by 2032. Leveraging the GREET model, the MACH2 estimates a total consumption of RNG of approximately 547,000 MMBtu per year, assuming a feedstock consumption rate of 0.2 MMBtu of RNG per Kg H_2.

<u>Waste streams:</u> Finally, in line with the GREET model, it is estimated that no relevant stream of wastewater is generated during the electrolysis process. The PGW project using SMR with RNG to produce orange H_2 will release steam as a byproduct. On average, it is estimated that 0.02 MMBtu/ Kg H_2, will be released, amounting to ~66,481 MMBtu of steam per year as per the GREET model. The PGW orange H_2 production project will produce GHG as a byproduct, this is accounted in the carbon intensity of orange H_2 in line with GREET model assumptions. The additional CCS that will be used will capture these GHG waste streams and reduce the carbon intensity to -6.5 Kg CO_{2e}/kg H_2. As mentioned on section 1.5 of this TEA section, an additional waste stream was considered to account for the waste from the CCS system, namely CO_2. This is approximately ~3.2 kg CO_2 captured per kg Orange H_2. [redacted]

Lastly, the MACH2 Hub includes several end-use projects involving clean hydrogen combustion through boilers and other fired equipment. Leveraging the GREET model the MACH2 team estimates that NOx emissions will amount to 60 grams/MMBtu of H2 or 6.91 grams NOx / Kg H_2 burnt by these end uses. Total demand involving H_2 combustion amounts to ~306 mt / year, which implies total NOx emissions of 640 Kg NOx / year for the H2 Hub in 2032. This number results from one of the key partners with a combustion related end-use, Hilco (250 mt in 2032), having plans to install scrubbers with an expected efficiency of 85% to reduce NOx release from their flue gas. Other partners will additionally assess opportunities to further reduce NOx release through scrubbing technology. It is also worth highlighting that the combustion of H_2 in these cases is replacing the use of natural gas which typically produces 41 grams per MMBtu of NOx and additional emissions i.e., 2.5 VOC, 25 CO, 3.5 PM10, 3.5 PM2.5, 0.3 SOx, 1 CH_4, 0.35 N_2O all in grams per MMBtu of natural gas. The use of H_2 is therefore key in reducing non-NOx industrial combustion emissions and will also reduce overall NOx emissions when used in combination with scrubbers. In addition, 32 mt H_2/ year destined to transportation-related end uses in fuel cell vehicles, will serve to decarbonize transport in the area while avoiding NOx emissions. MACH2's partners will comply with all federal and state-level regulations to treat any remaining water flows and steam byproducts.

In summary, the MACH2 Hub is well underway to develop a hub with overall negative CO_{2e} emissions during its lifecycle, estimating a weighted average MACH2 well-to-gate carbon intensity of around -0.17 Kg CO_{2e}/kg H_2 2024-2035, and stable lifecycle well-to-gate emissions of -0.14 Kg CO_{2e}/kg H_2. The Hub's strategic position and proximity to major airports and ports with a robust maritime industry presents an opportunity to aid in not only the decarbonization of major airports, but also in the growth of hydrogen as a fuel for shipping and the growth of renewable ammonia production in the Mid-Atlantic.

Data Collection and Reporting
Overall data reporting and collection will be a centralized effort that the MACH2 hub will establish from the formation of the hub. Utilizing a centralized PMO (Project Management Organization) a detailed list of reports will be generated based on each requirement identified by the DOE and the MACH2 management team. The requirements will cover all identified criteria in the FOA as well as any critical reports that are not included in the FOA but must be monitored for the operation of the hub. A series of OKRs (Objectives & Key Results) and KPIs (Key Performance Indicators) will be developed that will be continually reviewed as the hub develops and matures. The PMO team will utilize recurring steering meetings to decide and set standards for reporting for the subsequent period as well as review reports and gaps from the previous cycle. This agile governance framework will allow the hub to adapt to changing conditions and fully capture the required reporting as the hub matures. Using this framework, a series of recurring meetings and reports will be established using a prescribed cadence. Throughout each subsequent phase, the maintenance of an activist PMO organization will push to generate accurate reporting while actively solving any pain points or data gaps that come up over the course of the lifetime of the hub. The end result of this process will be the establishment of a robust data collection and monitoring organization that will require buy-in from partner organizations and projects.

Part 6: Workplan

Project Objectives
The goal of MACH2 is to develop an economically and operationally sustainable predominantly green hydrogen hub with production, distribution and contracted supply to diverse end uses in as safe and socially responsible as possible. Achieving this goal will require overall hub development coordination and well-managed partner project planning and construction execution for their capital projects production, distribution and receiving assets; excellence in operations with safety as the priority for all aspects of the hydrogen supply chain; a robust program for community benefits and environmental justice; deployment of skilled union labor and coordinated training programs to fill the jobs created by providing opportunities to individuals in underserved communities.

The proposed MACH2 Hub, which consists of the State of Delaware, Southeastern Pennsylvania, and Southern New Jersey, is uniquely positioned to achieve the stated goal. These regional and local governments support advancing the decarbonizing of energy and commitment to environmental justice; a unionized work force with decades of experience in the construction and operation of energy and chemical production assets; "blue chip" industrial partners participation, all with a culture of safety and experience in major project development; the support of regional educational institutions to develop training programs and support community outreach; the legacy of energy production within the Hub that reduces capital by repurposing out-of-service assets and that may provide future connectivity to adjacent hubs, together with a seasoned professional MACH2 leadership team, augur for success.

As part of establishing the MACH2 Hub the following will be achieved:

1) The generation of clean and predominantly zero-emission green and pink hydrogen to supply the local energy economy and the mitigation of greenhouse gas emissions.
2) Reuse and revitalize significant existing pipeline infrastructure and heavy industry sites in a formerly industrialized and still densely populated region.
3) Create and retain more than 13,000 well-paying union jobs and generate a new talent pipeline in the clean energy sector.
4) Provide economic opportunity and health improvements to directly benefit historically underserved communities in alignment with President Biden's Justice40 objectives.

Technical Scope Summary

MACH2 plans for the production, distribution, and end use of ~271 tons/day of hydrogen from ten production sites by Phase IV to be distributed by a 50-mile "open stock" pipeline network connecting multiple producers with end users for industrial use, power generation and transportation applications. In addition to the primary pipeline system smaller pipeline projects of less than 2 miles may also be constructed to optimize distribution (i.e., Philadelphia Gas Works (PGW) pipeline from Richmond Ave. production to Tioga Terminal). Truck delivery will supply users located away from the pipelines. MACH2 is populated with several companies having extensive pipeline operations and experience including Enbridge, PGW, Buckeye, PECO, Fortress, PSEG, and other major mid-stream partners.

Table 41: MACH2 Production Projects

Project	Type	Year	Production (tpd)	Distribution	Potential user
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
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[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted] This project, together with a 5-mile pipeline from Twin Oaks to Marcus Hook, PA, mentioned below, will connect the entire north-south axis of

$MACH_2$. The second project is the removal and replacement of the Inter Refinery Pipeline (IRPL) between Marcus Hook and Hilco Bellwether which is also approximately 24 miles in length. Other smaller pipeline projects to efficiently connect supply with demand are listed in the technoeconomic analysis section. There is approximately 8-9 miles of ROW needed to be acquired, however, as these pipelines are in industrial areas with existing utility or industrial controlled ROW, we are not expecting difficulty in acquiring them. There will be pressurized truck loading built at PGW sites at Passyunk and Richmond Ave., PBF Delaware City and at the Holtec production sites in southern NJ. Construction of additional truck loading facilities at locations along the pipeline routes will be considered to optimize distribution.

Table 42: MACH2 Demand Projects

Partner	Year demand starts	Category	Max. demand (tpd)
SEPTA	2024	Transportation	23.8
Philadelphia Municipal Fleet	2024	Transportation	5.8
DRS	2024	Transportation	2.7
DuPont	2027	Boiler fuel	2 (potential up to 50)
Monroe	2026	Boiler fuel	50
Croda	2026	Boiler fuel	2
Hilco	2028	Microgrid	251.2

MACH2 will develop plans including contingency plans to proactively balance hydrogen supply and demand through the construction and implementation phases after production and offtake capacities are confirmed during future engineering and construction schedules are developed I greater detail. The supply and demand numbers are dynamic, and we anticipate significant demand growth in the near future as security of supply and accessibility are proven. Many companies we engaged with are pursuing decarbonization, but they were unable to provide projected hydrogen demand figures and are just now contemplating budgeting for a transition. Pipelines within the MACH2 Hub will be strategically sized to facilitate hydrogen transport for these additional projects. Examples of expected future demand:

- New Jersey Transit, whose long-haul routes are not suited for batteries
- DART is interested in converting their fleets long term to use hydrogen
- New Jersey American Water – H_2 fuel cell microgrids for back up generation at water treatment plants and large vehicle fuels throughout the Hub
- DuPont, establishing a H_2 fuel cell microgrid at the Experimental Station Research Center in Wilmington Delaware
- Monroe Sustainable Aviation Fuel (SAF) production facility

These and other demand are likely to materialize and can be met with additional production in the Hub. MACH2 reviewed more production projects than we elected to promote for funding that will be justified if demand appears to exceed planned production. Air Liquide has interest in production and PSEG has interest in a second project. MACH2 has several excellent industrial sites available for development, many with easy pipeline access as they were former chemical plants or oil terminals, remediated and now capped. All production sites will be newly built and are where most of the DOE funding will be applied. PSEG, Enbridge, Messer are working closely with landowners on sites with pipeline access and we expect MOUs shortly. sHYp, and

Versogen have not identified sites, but they have time as we elect to fund these enterprises only in Phase 4 and 5 once their respective technologies have proved commercial viability. The remaining production sites are owned or controlled by the respective producer. PBF, the largest producer at 76 tons per day, is the largest planned recipient of DOE funding.

MACH2's total project timeline commences on March 1, 2024, and runs through February 28, 2034. The Hub's design and buildout is broken into four (4) distinct Phases. Phase 1 commences on March 1, 2024, and runs until May 31, 2025. Phase 1 will encompass initial planning and analysis activities to ensure that the overall Hub concept is technologically and financially viable. Phase 2 commences on June 1, 2025, and runs through February 28, 2028. Phase 2 will finalize engineering designs and business development, site access, labor agreements, permitting, offtake agreements, and community engagement activities. Phase 3 commences on March 1, 2028, and runs through February 28, 2031. Phase 3 will focus on installation, integration, and construction activities. And finally, Phase 4 commences on March 1, 3031 and runs through February 28, 2034. Phase 4 will ramp up the Hub to full operations including data collection to analyze operations, performance, and financial viability. All major project component parts are depicted on the Integrated Project Schedule for the four (4) Phases. $MACH_2$ has various types of electrolyzers being considered for hydrogen production. This includes proven technologies such as Alkaline, Solid Oxide, and Proton Exchange Membrane, as well as two novel technologies. These new technologies with one utilizing salt water as feedstock and the other an ion exchange membrane will generate additional production opportunities within the Hub, once proven technically viable and commercial. Each production site will choose the optimum technology for their site based on availability of steam or the type of water supply. As for the end users, both hydrogen fuel cell electric vehicles and internal combustion engines that can utilize hydrogen as a fuel are being considered. To effectively manage all the various projects across the $MACH_2$ ecosystem, $MACH_2$ will form a full management team from CEO to various department heads such as technical, financial, legal, etc. within a non-profit organization that will have all the necessary positions to coordinate and monitor the projects, hire subject matter experts when needed, and report out to the Department of Energy (DOE) as required.

WBS and Task Description Summary

An important aspect of the MACH2 Hub's development is the coordination and management of all projects within the Hub. MACH2 will hire and rely upon various subject matter experts who will have the responsibility and accountability to see all projects are brought to a satisfactory conclusion. In addition, MACH2 has partnered with many organizations that have deep experience in large capital construction projects. Between in-house expertise, hired expertise and highly experienced Hub partners, MACH2 is well positioned to complete all projects.

There are specific go/no-go milestones that need to be met to advance to the next Phase under each phase of the DOE's project planning guidelines. It will be the responsibility of the $MACH_2$ Management Team that all aspects are accomplished within a given Phase to enable $MACH_2$ and its project partners to advance to the next Phase. Activities that the $MACH_2$ Management Team will be responsible to oversee and manage include the following:

- Ensuring that all construction site selections have been finalized, and that site surveys and assessments are completed.
- Ensuring under Phase 1 that the early engineering studies performed meet the 30% requirement.
- Regulatory and permitting engagement is started / in process.
- The development and project cost estimates and schedules are updated and finalized.
- Risk and contingency plans are established.
- Right of Way (ROW) issues are identified early and resolution or plans to resolve are being executed.
- All regulatory requirements are on schedule to not impede further project development.
- Continuously monitor Hub-level risks, TRL and technology choices.
- Dynamic modeling of Hub level supply and demand.
- Monitor and ensure that Hub-level development costs and delivered hydrogen cost to end users remains cost competitive.
- Phase 1 Scope of the Community Benefits Plan implemented.

For each subsequent Phase, the same methodology will be utilized. That is to adhere strictly to the DOE's Phase planning guideline knowing that failure to comply may result in $MACH_2$ being prevented from receiving further DOE funding. $MACH_2$ believes that the project partner organizations that make up $MACH_2$ are large enough to accomplish all the tasks required by each Phase. Most of MACH2's partners have in-house engineering capability and have the financial wherewithal to hire outside engineering expertise if so needed. Many of them also have in-house real estate organizations to assist with needed site selection. Since many of MACH2's partners are experienced managing large projects, they understand the critical path impact of long lead time material procurement. These critical path materials can have a direct impact progressing to the next Phase. As noted, two later phase projects utilize new technologies that may fail to develop to the TRL commercialization level; these projects will only receive $MACH_2$ after technology maturation.

Each project to be developed will require close coordination between the project development organization and the $MACH_2$ Management Team. This close coordination will ensure that every requirement per Phase is accomplished so that when MACH2 reports back to the DOE on project progress, each project will successfully pass and move on to the next Phase. A Work Breakdown Structure (WBS) normally contains three critical sections.

- Describe the breakdown or composition of work in tasks and activities managed by the MACH2 organization (community benefits, PEIS, overall coordination, etc.)
- Schedule the project work. Task and activities for the projects are broken out by phases.
- Develop Task and activities for projects, essentially EPC activities and estimate the cost of each task.

For the purposes of this summary, a detailed description of the various project tasks is included. The work breakdown structure and schedule for each project is covered under the Integrated Project Schedule. All project cost estimates are covered under a separate section of this application. A summarization of the major projects and activities in the overall Hub development by phase is given in the following paragraphs.

Phase 1 – March 1, 2024, through May 31, 2025 (15 Months)

Phase 1 will encompass initial planning and analysis activities to ensure that the overall Hub concept is technologically and financially viable. In addition to detailed engineering and the financial indications and implications of this engineering period, the following activities will occur in Phase 1.

Several technologies will be proven during this Phase. These include **Smartpipe** which is planned to be used for lining existing pipelines to allow for the transportation and storage of hydrogen and should be approved for hydrogen use by the end of Jan. 2024. **sHYp** electrolyzer technology, which will allow the utilization of saltwater as feed to the electrolyzer, and **Versogen** electrolyzer technology which utilizes an ion exchange membrane (AEM), which uses earth-abundant materials. The two (2) electrolyzer projects will not be considered for funding util they reach commercial scale and the Smartpipe technology will not be used within the Hub until it passes all regulatory requirements. Should Smartpipe technology be delayed, commercially available steel piping can be substituted.

Table 43: Production Project Phase 1 Detail

PSEG / H2 Production (Rapauno, NJ)	In addition to the detailed engineering and financial verification required for this Phase, the PSEG team will finalize a site selection for this project (several viable sites are currently under consideration), finalize the electrolyzer technology to be used for this project and procure same along with other Balance of Plant (BOP) equipment, spec out and begin to procure long lead time equipment, and secure all necessary federal permits for this project. No new technology development is anticipated.
Holtec Salem / H2 Production (Hope Creek, NJ)	In addition to the detailed engineering and financial verification required for this Phase, the Holtec team will begin the process to obtain all necessary permits for this project, will perform a detailed HAZOP, which is a risk assessment technique which adopts a systematic way to identify possible hazards in a work process, and select an electrolyzer technology and procure same. Plant construction begins first quarter 2025. No new technology development is anticipated.
Enbridge / H2 Production (Paulsboro, NJ)	In addition to the detailed engineering and financial verification required for this Phase, the Enbridge team will make a Final Investment Decision (FID) and complete the permitting process. Plant construction to commence the first quarter 2025. No new technology development is anticipated.
Messer / H2 Production Project (Site TBD)	In addition to the detailed engineering and financial verification required for this Phase, the Messer team will determine a site for plant construction and will make a Final Investment Decision (FID) and begin the permitting process. Plant construction to commence first quarter 2025. No new technology development is anticipated.
Chesapeake Utilities / Small Scale Solar Electrolysis (Georgetown, DE)	In addition to the detailed engineering and financial verification required for this Phase, the Chesapeake Utilities team will continue pursuing and complete this project's permitting, electrolyzer selection, and purchase and will be well on their way to constructing the plant. No new technology development is anticipated.
PGW / H2 Production (Port Richmond, Philadelphia)	In addition to the detailed engineering and financial verification required for this Phase, the PGW team will begin permitting activities, begin their procurement process, and look to begin plant construction in the beginning of Phase 2.
PBF / H2 Production (Delaware City, DE)	PBF anticipates continued engineering development starting in the fourth quarter of 2023, with FID and initiation of plant construction in fourth quarter of 2024.

<u>Offtake and End Use</u>
Southeastern Pennsylvania Transportation Authority (SEPTA): Beginning in January 2024, SEPTA will receive its first hydrogen fuel cell electric (HFCE) bus. Nine more HFCE buses will be received into the SEPTA system by June 2024 as part of the pilot program. The first bus delivered in January 2024 will be used as test case to work out route and operating issues. These ten buses will be supplied hydrogen by means of a hydrogen tube trailer.
City of Philadelphia Municipal Fleet: The first hydrogen fueled trash trucks and street sweepers are planned to be delivered to the City of Philadelphia's Municipal Fleet beginning December 2024. Unlike the SEPTA buses, the Municipal Fleet will utilize internal combustion engines having the capability to burn hydrogen instead of diesel.

Phase 2 – June 1, 2025, through February 28, 2028 (33 Months)
Phase 2 will finalize engineering designs and business development, site access, labor agreements, permitting, offtake agreements, and community engagement activities. The following activities will continue to progress in Phase 2: **sHYp** electrolyzer technology should complete its second pilot phase by the end of Q2 2025, and **Versogen** electrolyzer technology should complete its second pilot by the end of Q2 2026.

Table 44: Phase 2 Production Scale-Up Detail

PBF / H2 Production (Delaware City, DE)	PBF anticipates plant startup in third quarter of 2027 with gradual ramp up to full production.
PSEG / H2 Production (Site TBD)	Procurement of all necessary equipment should be completed by the end of the first quarter 2026. State permits should be secured by the end of the second quarter 2025 and local permits by second quarter 2026. Plant construction starts first quarter 2026. Plant startup anticipated by the end of the fourth quarter 2027.
Holtec Salem / H2 Production (Hope Creek, NJ)	All necessary permitting should be secured by the third quarter 2025. Hydrogen plant construction should begin the first quarter 2025 and to be completed the end of the fourth quarter 2026.
Enbridge / H2 Production (Paulsboro, NJ)	Plant construction completed end of first quarter 2027.
Messer / H2 Production (Site TBD)	All permitting to be completed by first quarter 2026. Plant construction to be completed fourth quarter 2027.
Chesapeake Utilities / Small Scale Solar Electrolysis (Georgetown, DE)	Plant startup scheduled for third quarter 2025.
PGW / H2 Production (Port Richmond, Philadelphia)	PGW completes their project in the second quarter 2027.
Holtec / Small Modular Reactor (Oyster Creek, NJ)	This project will begin development in the fourth quarter 2027. Note that the SMR is a new design and may have associated technical and permitting challenges. In lieu of the SMR, the project may elect to power the electrolyzer via renewable energy power from a project currently expanding generation capacity.

<u>Offtake and End Use</u>
SEPTA and the City of Philadelphia Municipal Fleets continue to increase their demand for hydrogen fuel in Phase 2 as additional vehicles are delivered or converted to hydrogen use. At the end of second quarter 2026 Monroe begins using hydrogen to feed their boilers and at the

end of second quarter 2027 DuPont begins using hydrogen to feed their boilers.
Pipelines: Various pipeline lift and lay or expansion projects begin in the fourth quarter 2025 with target completion in early Phase 3.

Phase 3 – March 1, 2028, through February 28, 2031 (36 Months)

Phase 3 will focus on installation, integration, and construction activities.

Table 45: Phase 3 Activity Detail

sHYp	Electrolyzer technology should complete its third pilot phase by the end of the second quarter 2028; sHYp should be ready to begin plant construction the first quarter 2028 and be in full production by the first quarter 2030
Versogen	Electrolyzer technology should complete its third pilot phase by the end of the third quarter 2029; Versogen should be ready to begin plant construction the fourth quarter 2028 and be in full production by the fourth quarter of 2030
Holtec Oyster Creek	In addition to the detailed engineering and financial verification required for Holtec's second project, the Holtec team will begin the process to obtain all necessary permits for this project, will perform a detailed risk assessment technique, and select an electrolyzer technology and procure same. All these activities will be commenced and completed in Phase 3

Offtake and End Users:
SEPTA and the City of Philadelphia Municipal Fleets continue to increase their demand for hydrogen fuel in Phase 3. **Hilco** should be ready beginning in the second quarter 2028 to receive hydrogen to power a microgrid, and possibly to use as full for heavy transportation calling their facilities.

Phase 4 – March 1st, 2031, through February 28th, 2034 (36 Months)

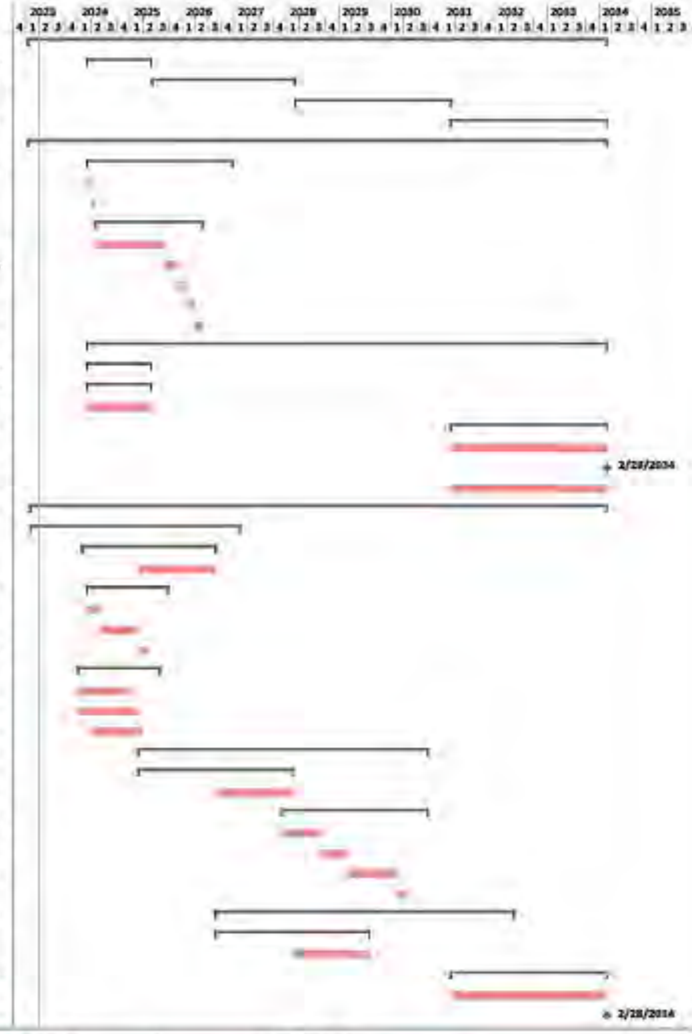
Complete any unfinished projects and ramp up to full Hub Operation.
Go/No Go Decision Points: $MACH_2$ will rigorously manage the Hub's program and ensure projects progress adequately to successfully meet all DOE requirements for phase transitions. Please see the Integrated Project Schedule (IPS) section for a comprehensive current view of all the Hub's Go/No Go decision points.
End of Project Goals: $MACH_2$ will strive to complete all requirements within the four (4) Phases. At the end of Phase 4 the following project goals are expected to be met:

- Establishment of a financially sustainable hub in the Mid-Atlantic region,
- A hub that has greatly improved the environment,
- A hub that has trained and will continue to train and develop the next generation of energy workers to be fully familiar and competent in the production, transportation and end users of hydrogen,
- A hub that has increased the wellbeing of old energy infrastructure fence line communities, especially from a medical perspective,
- And a hub that has provided good paying jobs to underserved communities.
- A plan to transition a region from reliance on fossil fuels to hydrogen and the associated decrease in GHG emissions.

Integrated Project Schedule:
Please note that the EPC data points, milestones, and the Community Benefits Plan's milestones will be detailed in the Integrated Project Schedule.

Figure 22: IPS - Critical Path

ID	Task Mode	Task Name	Text1	Duration	Start	Finish
1		MACH2 H2 HUB Integrated Project Schedule	Project Type	145.05 mons	Mon 1/16/23	Tue 2/28/34
2		Phase 1		16.1 mons	Mon 3/4/24	Wed 5/28/25
6		Phase 2		35.8 mons	Mon 6/2/25	Tue 2/29/28
10		Phase 3		39.05 mons	Wed 3/1/28	Fri 2/28/31
14		Phase 4		39.05 mons	Sat 3/1/31	Tue 2/28/34
17		Milestones		145.05 mons	Mon 1/16/23	Tue 2/28/34
48		Programmatic Environmental Impact Statement (PEIS)		36.5 mons	Mon 3/4/24	Sat 12/19/26
49		Project Scoping and Scheduling		1 emon	Mon 3/4/24	Wed 4/3/24
50		Notice of Intent (Publish in Federal Register)		1 emon	Wed 4/3/24	Fri 5/3/24
51		Agency and Local Official Coordination for NEPA		26.8 mons	Fri 5/3/24	Sat 5/23/26
52		Conduct Technical Studies / Assessment of Effected Environment		16 emons	Fri 5/3/24	Tue 8/26/25
53		Draft Environmental Impact Statement		3 emons	Tue 8/26/25	Mon 11/24/25
54		Conduct Public Notice and Hearing		2 emons	Mon 11/24/25	Fri 1/23/26
55		Issue Final Environmental Impact Statement		2 emons	Fri 1/23/26	Tue 3/24/26
56		Record of Decision (Publish in Federal Register)		2 emons	Tue 3/24/26	Sat 5/23/26
61		Community Benefits Plan Activities		130.3 mons	Mon 3/4/24	Tue 2/28/34
62		Phase 1 - Detailed Planning		16.1 mons	Mon 3/4/24	Wed 5/28/25
87		Justice40 Initiative		16.1 mons	Mon 3/4/24	Wed 5/28/25
88		Identify affected Disadvantaged Communities (DAC) and non-DAC communities and concerns of industry partners		15 emons	Mon 3/4/24	Wed 5/28/25
109		Phase 4 - Ramp Up and Operate		39.05 mons	Sat 3/1/31	Tue 2/28/34
110		Evaluate and monitor C&L activities and efforts		36.47 emons	Sat 3/1/31	Tue 2/28/34
113		Issue Evaluation Report		0 mons	Tue 2/28/34	Tue 2/28/34
114		Maintain DAC and non-DAC Justice40 Program		36.47 emons	Sat 3/1/31	Tue 2/28/34
115		Engineer, Procure and Construct		144.45 mons	Wed 2/1/23	Tue 2/28/34
116		Phase 1		52.6 mons	Wed 2/1/23	Fri 2/12/27
117		Technology Development - Phase 1		33.35 mons	Wed 1/31/24	Fri 8/21/26
120		Versogen Pilot Plant - Phase 1		18 emons	Thu 2/27/25	Fri 8/21/26
136		Holtec Salem Hope Creek Project - Phase 1	Production	20.4 mons	Mon 3/4/24	Thu 9/25/25
137		Stakeholder and Fatal Flaw Review		3 emons	Mon 3/4/24	Sun 6/2/24
138		FEED engineering and economics verification		9 emons	Sun 6/2/24	Thu 2/27/25
139		Select / Award H2 generation module contract		2 emons	Thu 2/27/25	Mon 4/28/25
152		Chesapeake Small Scale Solar Electrolysis H2 Production Project	Production	20.4 mons	Tue 1/2/24	Fri 7/25/25
153		Detailed Engineering		12 emons	Tue 1/2/24	Fri 12/27/24
154		Permitting Activities (Ongoing)		14 emons	Tue 1/2/24	Tue 2/25/25
155		Procurement		12 emons	Mon 4/1/24	Thu 3/27/25
176		Phase 2		72.45 mons	Thu 2/27/25	Tue 9/17/30
177		Technology Development - Phase 2		38.6 mons	Thu 2/27/25	Sat 2/12/28
179		Versogen Pilot Plant - Phase 2		18 emons	Fri 8/21/26	Sat 2/12/28
189		Holtec Oyster Creek Project - Phase 2	Production	36.4 mons	Thu 12/2/27	Tue 9/17/30
190		SMR 160 Development		9 emons	Thu 12/2/27	Mon 8/28/28
191		Stakeholder and Fatal Flaw Review		6 emons	Mon 8/28/28	Sat 2/24/29
192		FEED Engineering and economics verification		12 emons	Sat 2/24/29	Tue 2/19/30
193		Select / Award H2 generation module		2 emons	Tue 2/19/30	Sat 4/20/30
203		Phase 3		74.75 mons	Fri 8/21/26	Thu 5/13/32
204		Technology Development - Phase 3		38.55 mons	Fri 8/21/26	Sun 8/5/29
206		Versogen Pilot Plant - Phase 3		18 emons	Sat 2/12/28	Sun 8/5/29
217		Phase 4		39.05 mons	Sat 3/1/31	Tue 2/28/34
218		Expansions and Operations		36.47 emons	Sat 3/1/31	Tue 2/28/34
219		MACH2 Hub Complete		0 mons	Tue 2/28/34	Tue 2/28/34



Project: MACH2 IPS 31-Mar-2023 Rev C Critical Path
Date: Fri 3/31/23

Task, Split, Milestone, Summary, Project Summary, External Tasks, External Milestone, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, Deadline, Critical, Critical Split, Progress, Manual Progress

Figure 23: IPS - Full Schedule With Predecessors and Successors (1 of 3)

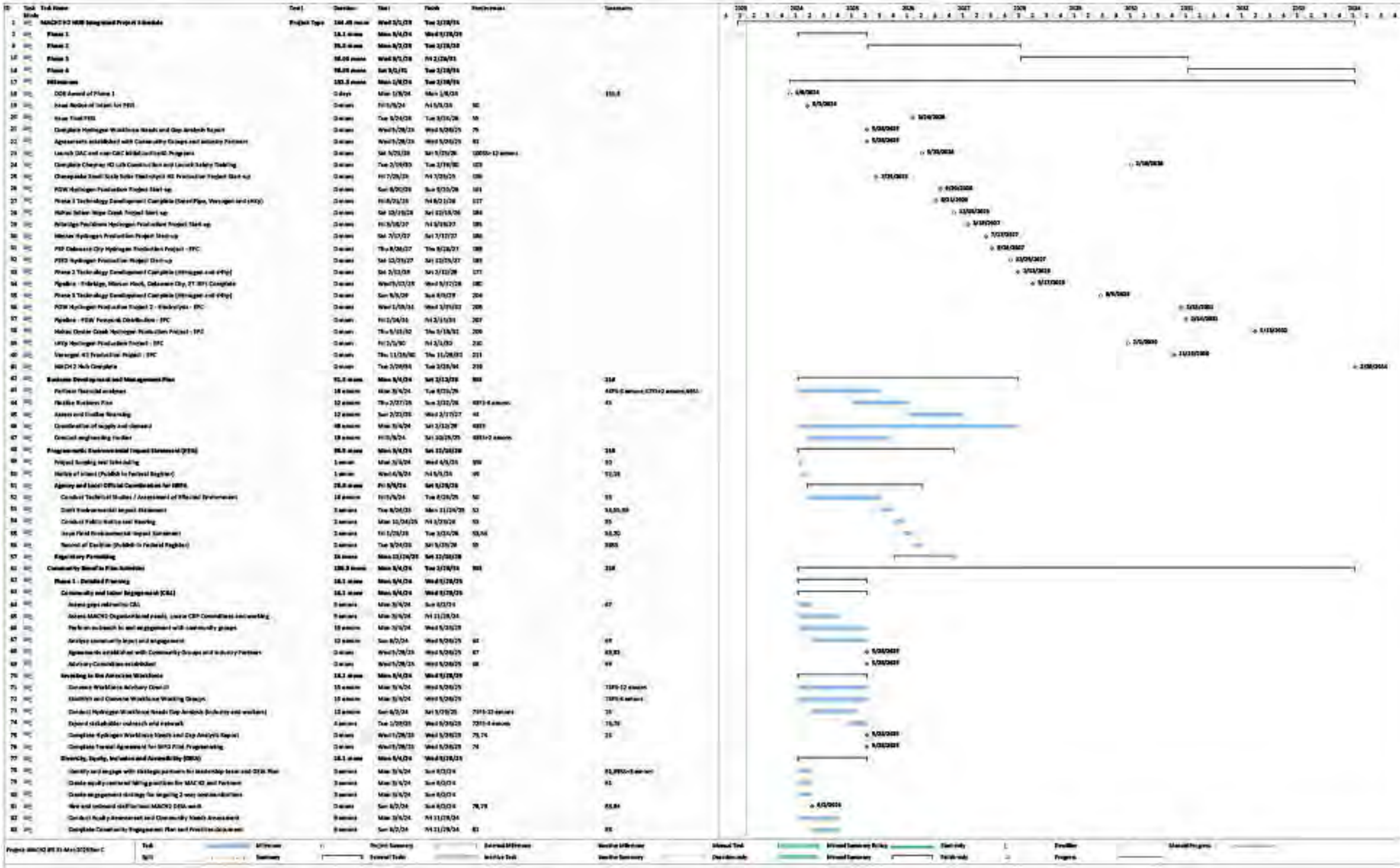


Figure 24: IPS - Full Schedule With Predecessors and Successors (2 of 3)

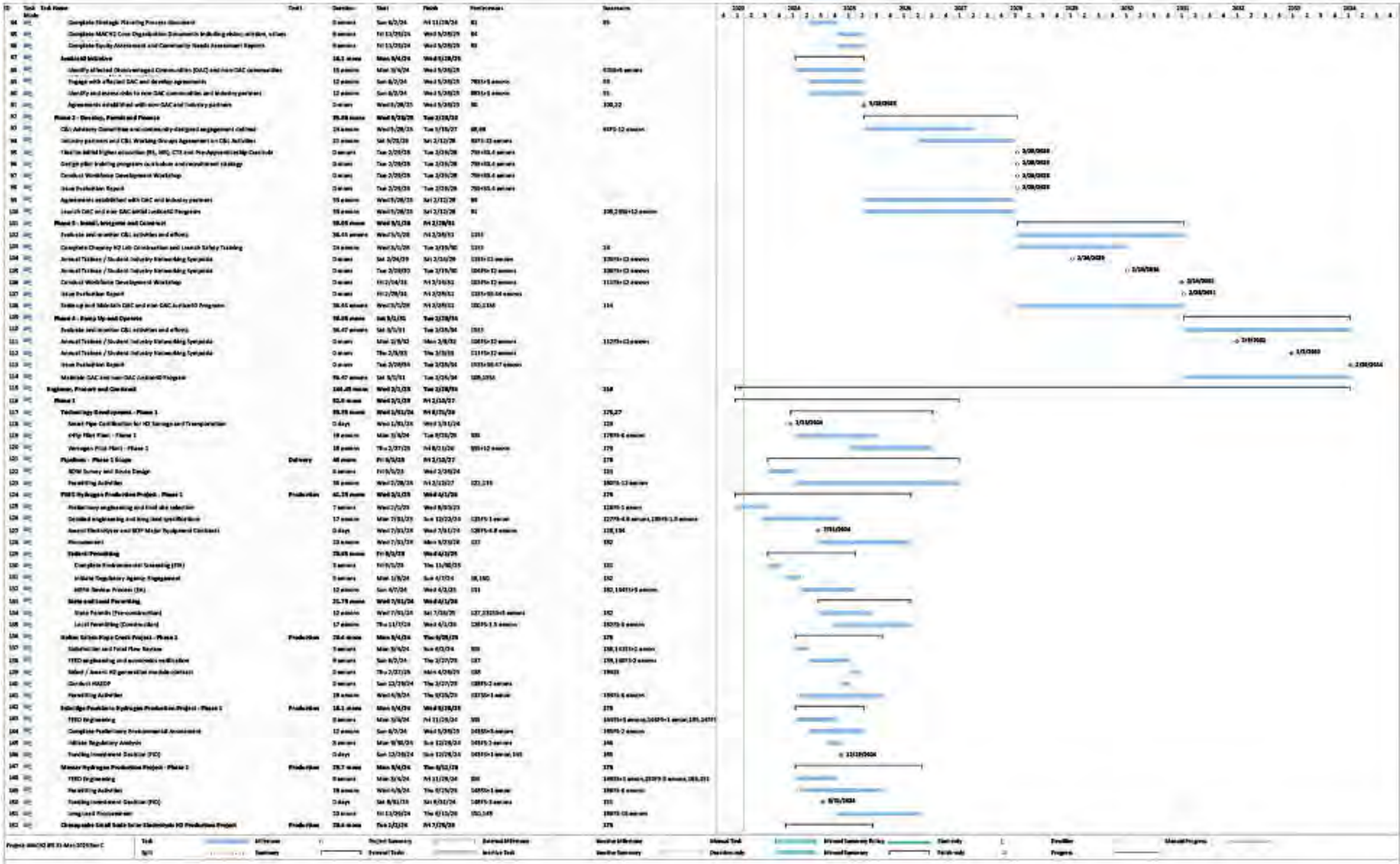
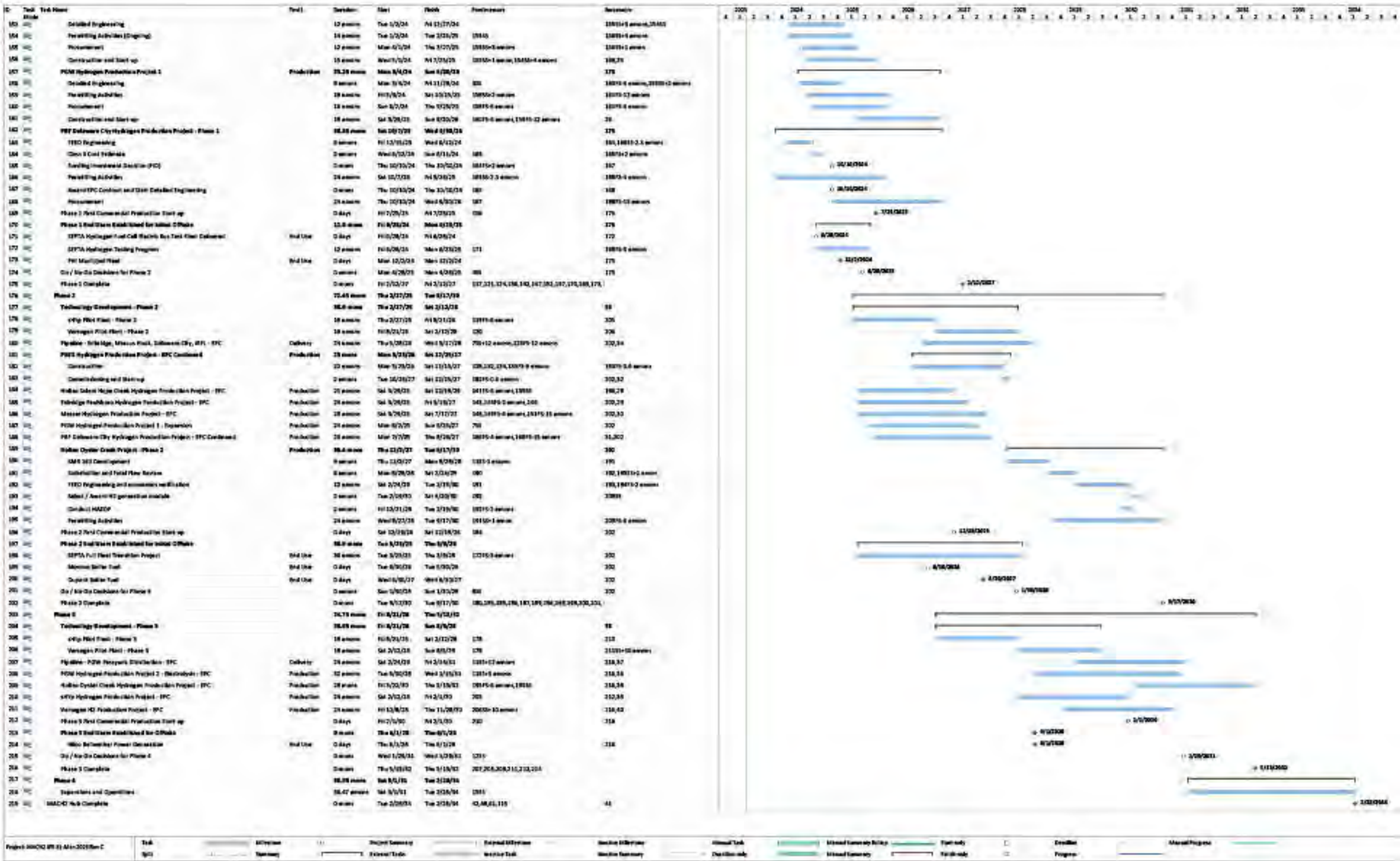


Figure 25: IPS - Full Schedule With Predecessors and Successors (3 of 3)



Appendix A: Transfer of OCED Exchange Control Number

2779-1593: Mid-Atlantic Clean Hydrogen Hub (MACH2)

This document is to affirm that the Mid-Atlantic Clean Hydrogen Hub's OCED Exchange Control Number (2779-1593) is being transferred from the lead organization in our concept paper to the lead organization in our full application. Those organizations are:

Concept Paper
Lead Organization: City of Philadelphia
UEI: K3LGS8BABNH9

Full Application
Lead Organization: Mid-Atlantic Clean Hydrogen Hub, Inc.
UEI: MGLXWA4CWCH3

Signed,

City of Philadelphia
Project Lead/Principal Investigator
Manny Citron
Manny.citron@phila.gov
[redacted]

Mid-Atlantic Clean Hydrogen Hub, Inc.
Business Point of Contact
Dora Cheatham
[redacted]

Appendix B: Cost Share Commitment Verification

2779-1593: Mid-Atlantic Clean Hydrogen Hub (MACH2)

This document is to affirm that the leadership of Mid-Atlantic Clean Hydrogen Hub, Inc. commits to at least 50% cost share for all hub activities and has communicated the minimum 50% cost share requirement with all major project partners, and those partners have explicitly expressed their commitment to adhere to this requirement.

For the duration of the project, the ratio of Federal Share to Cost Share is 72.29%.
Federal Share: $839,580,350
Cost Share: $2,190,818,933

In Phase 1, the ratio of Federal Share to Cost Share is 83.43%.
Federal Share: 19,714,352
Cost Share: $99,252,583

Those organizations are:
1. Chesapeake Utilities
2. DuPont Experimental Station
3. Enbridge Energy
4. Hilco Redevelopment Partners
5. Holtec
6. Messer Industrial Gases
7. Monroe Energy
8. PGW
9. PSEG
10. PBF Energy
11. SEPTA
12. sHYp
13. Versogen

Mid-Atlantic Clean Hydrogen Hub, Inc.
Business Point of Contact
[redacted]

2779-1539: Mid-Atlantic Clean Hydrogen Hub (MACH$_2$)

MACH$_2$ thanks reviewers for their thoughtful feedback. This document addresses comments across sections. However, we aggregated similar comments and re-organized our response under topical sections. If a comment is not addressed in an expected section, please review other sections. A few comments requested extra documents (e.g., site layouts) that would exceed the page limit. In such instances we have provided a summary response and a weblink to documents that may be reviewed at DOE's discretion (we recognize DOE may decide not to).

Project & technology details | The MACH$_2$ hub consists of 11 H_2 production projects; 8 projects deploy technologies with TRL8+, ensuring 70%+ of total hub H_2 production (190 mtpd by 2032) – far exceeding minimum requirements of 50-100 mtpd. The remaining 3 production projects with TRL6 or lower come online in later years, providing sufficient time for technology maturity. These 3 projects each have an identified pathway to TRL of 8+ ahead of hub H_2 production:

Versogen will deploy anion exchange membrane (AEM) electrolyzer producing 24 mtpd H_2 in 2029 and scaling up to 64 mtpd by 2035. Versogen's pathway to TRL9 is as follows:

Year	TRL	Anion exchange membrane (AEM) electrolyzer
2023	6	Megawatt platform stack has been tested demonstrating > 1kW/cell (2Q 2023)
2024	7	1MW stack-built w/ performance & durability testing by 4Q 2024 & 3Q2025, respectively
2025	8	1MW system field tested (4Q 2025)
2026	9	5MW system field tested and ready for deployment in MACH$_2$ (3Q 2026)

sHYp's H_2 electrolyzer is a membrane-less electrolyzer design that operates in an alkaline environment using seawater as the electrolyte source. The target capacity for MACH$_2$ is 4 mtpd by 2030 and 80 mtpd by 2033. sHYp's pathway to TRL9 is as follows:

Year	TRL	Seawater Processing System (Hydroxides)	TRL	Hydrogen Electrolyzer System (Hydrogen)
2023	6	System integration at prototype scale (500 W), 5 kg/day hydroxide production	5	Component durability to >1000 hrs in seawater composition
2024	7	Pilot scale system (100 kW); 1 mtpd	6	System integration at 500W scale; 0.2kgH_2/day
2025	8	1st Commercial demo (1MW); 4,000 tons/yr	7	10 kW on-land pilot (4 kg/day)
2026	8	2nd, 3rd commercial demonstration (1 MW)	7	100 kW on-land pilot (40 kg/day)
2027	9	Full commercial deployment at 1MW scale; sale of 10MW systems	8	1MW on-land commercial demonstration (0.4 mtpd); 100 kW offshore platform pilot
2028		Commercial systems at 1 – 50 MW scale	8	1MW offshore platform commercial demo.
2029			9	Additional 1MW commercial demonstrations
2030				Scale to 10MW (4 mtpd) and larger

Holtec's Small Modular Reactor SMR-160 at Oyster Creek combines existing technologies with new innovation and is based on current pressurized water reactor technology in use by 70% of US commercial nuclear fleet and 100% of US Navy nuclear reactors. Component systems TRL ranges from 4 to 8 (TRL by system: weblink) and Holtec's pathway to TRL 9 is as follows:

Year	TRL	Technology	SMR-160 TRL Progression Table
2024	6	Reactor & connected components	Completion of Integral and Separate Effects Testing (end '24)
2026	6	All systems, structures & components	NRC Construction Permit Application Compete (mid '26)
2028	7		SMR-160 Construction Commences (mid '28) NRC Operating License Application Submitted (end '28)
2031	7		Construction & Commissioning Complete (end '31)
2032	8		Fuel Load & Hot Functional Testing Complete (end '32)
2032	9		Commercial Operation Declared (end of 2032)

If the lower TRL projects are unable to achieve commercial maturity, the $MACH_2$ hub would proceed with remaining projects producing 190 mtpd H_2 at an LCOH of $3.86/kg H_2 by 2030.

Several commenters requested additional project details; please note project descriptions, technology, site and other details were provided in the application under Part 5: TEA. Additionally, we have summarized key project details below. Project site layouts and/or flow diagrams were available but not furnished in the application due to space limitations; layouts and/or diagrams are available for the H_2 production projects and can be found at this weblink.

Project	Capacity; technology (TRL; potential vendors); status	Financing Options
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Holtec Small Modular Reactor | Holtec is developing a pink H_2 project at the Oyster Creek site; the technology is based upon current pressurized water reactor technology in use by 70% of the US commercial nuclear fleet and 100% of US Navy's nuclear reactors. However, this project will produce green H_2 in the near term and transition to pink H_2 via construction of an SMR-160 nuclear plant. There is near term interest by offshore wind developers to bring power ashore to Oyster Creek switchyard via Holtec owned land. We expect wind electricity to be used to produce green H_2 in near term, with pink H_2 production in later years once nuclear power is available (unless first of its kind SMR-160 is developed and approved earlier than modeled).

PBF project | [redacted]

[redacted]

PGW Steam Methane Reforming | PGW is developing a steam methane reforming (SMR) H_2 production project paired with CCUS; SMR will use RNG at attractive prices from city waste streams, preventing current methane flaring and further reducing emissions. CO_2 sequestration in PA may be viable – per Team Pennsylvania 2022 "Successful Deployment of Carbon Management and H_2 Economies in the Commonwealth of Pennsylvania" report, PA has CO_2 storage capacity of 88.5 billion metric tons. Challenges to commercial development are primarily non-technical, policy, and regulation. Off-shore CO_2 sequestration may also be viable. PGW is also evaluating carbon offtake pathways such as concrete with a sizeable carbon footprint & potential CO_2 use – CO_2 can be permanently stored within concrete. PGW will also evaluate steel, fertilizer, enhanced oil recovery, food beverage & other markets.

The project will likely have air emissions permitting implications requiring AMS installation permits, plan approval, and/or operating permit modifications. Based on emissions estimates provided by a potential vendor and Philadelphia's status as an ozone non-attainment area, nitrogen oxides (NOx) would be most likely air pollutant driving permitting. SMR unit can be installed in a configuration uncontrolled for NOx or with selective catalytic reduction (SCR) to reduce NOx. In an uncontrolled configuration, ~0.86 short tons of NOx are generated per 1,000 kg of H_2 produced. Configured with SCR, the SMR system generates ~0.097 short tons of NOx per 1,000 kg of H_2 produced; these levels are expected to fall within the synthetic minor permit.

Initial production from the PGW facility will be delivered to end users by compressed gas tanker trucks to match lower initial demand volumes. End user fleet conversions are expected to increase demand over time, and support economics to connect the two axis points via pipeline.

Open stock pipeline system | The MACH$_2$ operation enables producers and buyers to inject and receive H_2 without waiting for commodity transit time. Like other gas pipelines, on or before the 15th day of every month, the pipeline operator will accept nominations from shippers (shippers may be producers, consumers or marketers). Nominations for pipeline transport will state volume, origin, and destination for ratable deliveries for the following month. Through continuous volumetric balancing for safe operation, operator will ensure facilities only receive amount nominated for their receipt and shippers injecting H_2 have arranged off-take or storage.

The Inter-Refinery Pipeline (IRPL) running from Marcus Hook, PA to Hilco Bellwether Development in Philadelphia connects large end-users of Hilco and Monroe to supply sites in Paulsboro and Rapauno (NJ), Marcus Hook area, and Chester (PA). The IRPL also transits adjacent to Philadelphia Airport where H_2 supply can facilitate development of H_2 fueled aviation. The IRPL can also supply truck loading facilities built along the pipeline. A ~1 mile extension of the IRPL (through Hilco & PGW property) allows truck loading operations at PGW's

Passyunk facility to supply SEPTA and Philadelphia Municipal Fleet. As demand and economics warrant, green H_2 production could be staged at PGW Passyunk, providing another supply source into the IRPL. When completed, the IRPL can transport ~450 tons per day with line fill capacity of ~2 tons. The shipping capacity of 450 mtpd exceeds aggregate demand of 338 mtpd comprised of Hilco, Septa (via trucks at IRPL supplied facilities), Monroe, and other end-users as described in the application. In early phases, the IRPL can serve as storage & transport.

The pipeline will be operated as a common carrier line; credit approved shippers from a pipeline connected site can buy, ship, or receive product. Given equidistance of origins and destinations across partners, we envision one tariff regardless of origin or destination on the IRPL– preventing shippers along IRPL from being disadvantaged by tariff differentials.

PBF Delaware City supply connects to IRPL by new pipeline in primarily existing right of way. A 24.4 mile, 12" diameter PBF line will be constructed from Delaware City to Twin Oaks (PA) and connected IRPL at Marcus Hook, with capacity of 137 mtpd. Local demand at Delaware City is expected to consume H_2, leaving pipeline capacity for additional shippers. Shipments from PBF Delaware City for delivery into IRPL connected delivery sites in northern $MACH_2$ will have a higher tariff as PBF pipeline tariff will be added to IRPL tariff. PBF Delaware City production will serve northern $MACH_2$ in early years and in later years, serve demand growth in southern $MACH_2$ (DART, DuPont, Port of Wilmington, Bloom Energy fuel cell farm). In later years, Versogen & sHYp H_2 production will come online in northern $MACH_2$ to supplement PBF supply.

The PBF Line from Delaware City to Twin Oaks (PA) will continue to be a valuable distribution asset even after Del City production is not solely required in IRPL for PA destinations. The PBF Line can connect into Port of Wilmington (DE) using Buckeye Pipeline controlled right of way. Truck loading terminals can be constructed along the PBF pipeline route for distribution to City of Wilmington and various fuel cell micro grids such as one being studied by DuPont Experimental Station campus or for fuel to Croda plant at Atlas Point. H_2 from the pipeline can replace the natural gas currently supplying the Bloom Energy fuel cell farm at Red Lion. The Delaware City connection into IRPL enhances supply security for all operations within $MACH_2$.

Due to additional permitting requirements for pipelines crossing rivers, H_2 production will commence ahead of pipeline completion, requiring storage capacity in early years. $MACH_2$ will synchronize production & take-off; measures include pressurized truck loading prior to pipeline completion with pressurized above ground storage at some sites prior to pipeline completion. As pipeline sections are completed, they can be used as interim storage. Additional storage will be driven by operating necessity & economics; $MACH_2$ is evaluating storage in large out-of-service pipelines sleeved with Smartpipe and/or building pressurized above ground storage.

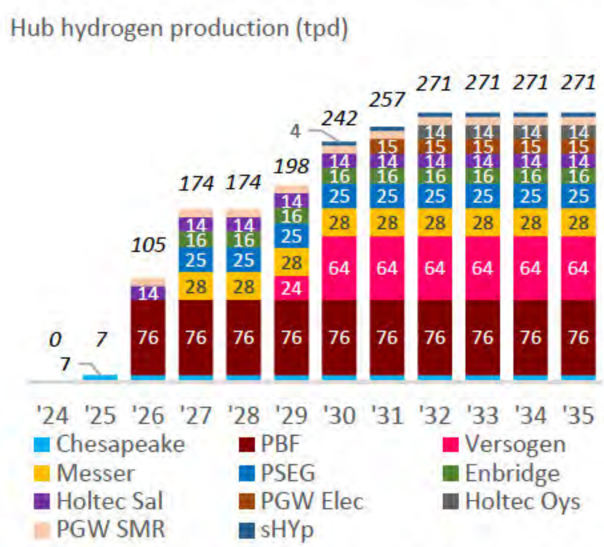
Smartpipe technology overview
Smartpipe is a mature product (TRL7; fully tested/certified under API 15s). Trenchless installation minimizes urban and environmental impact as it is pulled-through existing pipe (6" – 16" nominal pipe diameters). Such installation reduces carbon footprint of pipeline replacement by >70%. Smartpipe is a fully structural pipe installed in long-lengths (multiple miles) with embedded fiber-optics for continuous safety monitoring. DOE has reviewed Smartpipe for H_2 transport (ASME B31.12-2014).

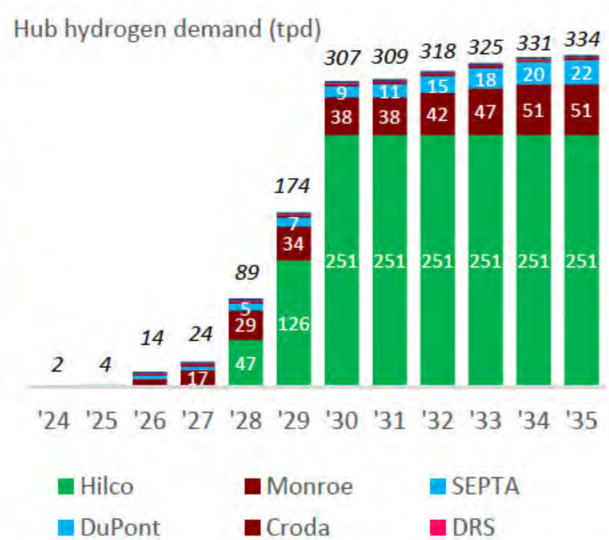
$MACH_2$ optimizes storage, distribution, connectivity to adjacent Hubs via reuse of legacy infrastructure. All 3 out-of-service petroleum refineries along Delaware River (Marcus Hook, Eagle Point and Philadelphia) offer unused, large diameter pipelines once used for crude oil supply and refined products. After demand connected to the IRPL is satisfied, these pipelines crossing over IRPL can be used for additional storage and distribution to incremental off takers. Additionally, the Buckeye large diameter pipeline connecting Eagle Point & Hilco Bellwether Site to Chelsea (PA) can be used for H_2 service and Buckeye line to Malvern PA intersects w/ IRPL at Paulsboro, NJ. Repurposing these lines will expand production, distribution, and use of H_2 within MACH$_2$.

Future additional production facilities which may have economic renewable or nuclear power supply and demand sites such as fuel cell electric microgrids, can be constructed at facilities near to repurposed pipelines and have immediate access to the MACH$_2$ pipeline infrastructure.

Examples MACH$_2$ connection opportunities with adjacent hubs
Using Buckeye Right of Way (Paulsboro, NJ to Rochester NY) and replacing sleeving existing line w/ Smartpipe
Colonial, Harbor, and East Line pipelines transport refined products from Philadelphia, to Linden, NJ, and were required when there were seven refineries operating in Philadelphia. Today, volume on the 14" diameter Harbor Pipeline can be shipped on the East Line, making the Harbor Pipeline available to retrofit for H_2 transport.
Trucks from Delaware City can supply Eastern Shore of Maryland

Supply & demand alignment | While discrete commitments between projects and off-takers will be determined in Phase 1, we have provided a summary of hub H_2 production by project and expected hub off taker demand by year below; this analysis aligns expected supply to expected demand. By design, MACH$_2$ prioritized off-taker demand to meet and/or exceed production to ensure financial viability of hub; excess demand will ensure individual projects can source and secure adequate demand to finance and develop H_2 production projects.





Safety | MACH$_2$ firmly believes safety, security, and environmental and regulatory compliance, are essential elements of successful hub development. Key MACH$_2$ partners such as PBF deploy compliant and market tested H_2 safety programs. PBF handles and consumes hundreds of tons of H_2 per day at each of its six refineries for hydrocracking, hydrotreating, isomerization, and refinery fuel gas systems for fired heaters. At five sites, H_2 is also produced as a direct product of steam methane reforming, and at all six sites H_2 is produced as a byproduct of certain refining processes. At certain locations, PBF also purchases H_2 generated off-site from third parties delivered by pipeline. PBF deploys and maintains dedicated H_2 supply systems for H_2 related processes. Operators, inspectors, and key staff are experienced with safety, mechanical integrity, and other risk concerns related to handling H_2, including flammability, reactivity, leak detection, H_2 cracking and embrittlement of metals, and other concerns. Partners such as PBF bring deep and tested safety experience across production, storage, transport, and use of H_2.

If awarded funding for Phase 1, $MACH_2$ will engage a safety expert responsible for developing a hub-wide overarching Safety Management Plan as a Phase 1 deliverable, ensuring the plan is ready for implementation prior to the conclusion of Phase 2 as required by the FOA. However, $MACH_2$ and its partners recognize the criticality of an embedded safety culture across the hub and as such we expect to develop & implement safety plans immediately after site, method of production, technology and capacity are selected for a given project; for some projects this may occur earlier in the process (e.g., before Phase 2 conclusion). The overarching safety plan will be site specific and/or operation specific depending on site activities. The safety expert will be responsible for aligning $MACH_2$'s Safety Management Plan and partner plans for a unified hub-wide safety approach. $MACH_2$'s Safety Management Plan will be based on established regulatory agencies guidelines such as, but not limited to the DOT, DOE, FERC, and OSHA. This approach ensures necessary permits are received expeditiously without adding additional layers of regulatory oversight to operations within fence lines of $MACH_2$ partner companies.

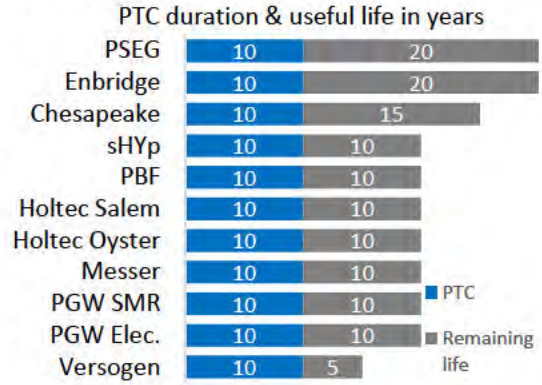
Partner	Safety ratings
Holtec	0.00 TRIR
Enbridge	0.40 TRIR
PSEG	0.63 TRIR
Versogen	0.00 TRIR
PBF	0.24 TRIR
Chesapeake	1.07 NCCI EMR

Unique to $MACH_2$, is an existing state-of-the-art training facility called Safety Town (Chesapeake owned). Safety Town (Dover, DE) provides a regional location to evaluate & qualify workers in controlled settings to operate under 49 C.F.R. 192.803 "Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards". Here, $MACH_2$ will conduct H_2 training & research for operators, first responders, regulators, educators, and community participants to develop H_2 experience prior to hub development. Additionally, MACH2 is partnering with Cheyney University, the nation's first HBCU, to establish a regional on-site, hands-on H_2 safety training program with support of Center for Hydrogen Safety at the American Institute of Chemical Engineers.

Cyber Security | Most $MACH_2$ partners, including Chesapeake, PBF, Monroe, ET, Enbridge, PSEG and Hilco, have deep experience in developing, managing, and testing robust cyber security plans to protect a broad set of sensitive energy and information infrastructure assets and project partners (e.g., equipment, services, software providers). If awarded funding for Phase 1, $MACH_2$ will engage services of a cyber security expert responsible for developing a $MACH_2$ hub-wide overarching Cyber Security Plan that integrates these individual company security plans as required in Phase 1 per FOA. This plan will incorporate all aspects of the DOE's Office of Electricity Delivery and Energy Reliability, Multiyear Plan for Energy Sector Cybersecurity (March 2018 version). Alongside a dedicated external cyber security expert, $MACH_2$ will leverage market tested experience of partners to develop a comprehensive cyber security plan during Phase 1, ready for implementation prior to conclusion of Phase 2, as required by FOA.

The cyber security expert will engage with the few smaller $MACH_2$ partners to develop and activate an organizational cyber security plan that meets requirements. All partner organizational cyber security plans will be individually validated and integrated into a $MACH_2$ Hub-wide overarching cyber security plan. The development, validation, and testing of the overarching cyber security plan will include an assessment and identification of key cyber risks across all $MACH_2$ hub components, as well as related penetration testing. The $MACH_2$ hub will leverage an external 3rd party for penetration testing; again, we will leverage expertise across critical $MACH_2$ partners that currently manages high risk energy infrastructure assets.

Financial and Market Viability | The $MACH_2$ Hub TEA analysis provided an overall hub LCOH of \$3.86/ kgH_2, which provides the weighted average cost of H_2 production across the life of the hub and assumes the production tax credit (PTC) for only allowable time horizons across each project beginning in Phase 1 of each project (later project phases are allocated <10 years of PTC). The LCOH is below expected market off take price of \$4.50-\$5.00/kgH_2, enabling financial viability of $MACH_2$ through its life. When pricing H_2, hub producers will take full project lifecycle costs into account across asset partial life, including understanding impact of PTC design as IRS finalizes guidance for 45V.



Go/No-Go Process | $MACH_2$ development will execute in 4 phases as described in the proposal and outlined in the FOA with each concluding using a "Go/ No Go" stage gate process that will include a comprehensive evaluation of the development based on readiness and maturity criteria. Each stage gate essentially creates a score card to determine if the $MACH_2$ development is ready to move into the next stage. Possible outcomes are (1) Proceed as planned (Go decision), (2) Proceed with revised plan or with recommendations in specific areas (qualified Go decision), or (3) Not ready to move to next stage (No Go decision). The stage gate process will begin 1-2 months prior to end of each phase concluding with Go/No-Go decision dates in the IPS. An additional set of Go/No-Go criteria will be applied to cornerstone projects; impacts to cornerstone projects may require modification to the overall hub development plan.

Go/No-Go criteria include (non-exhaustive):		
Technical	Community	Investment & Financing
Commercial	Environmental	Socialization & Outreach
Economics	Regulatory & Permitting	Stakeholder Alignment

$MACH_2$ Cornerstone projects	
PBF	Key production supplier, especially in later development phases. If plant expansion plans change or delay, a potential significant supply and demand imbalance may arise. The related pipeline refurbishment in existing ROW from Delaware City to Twin Oaks is also a key project
IRPL pipeline	Key infra. project transporting H_2 between partners; transport backbone of regional hub
Monroe	Producer & significant end user via process heater/furnace & renewable diesel and/or SAF projects. While not all projects are included in hub funding plan, they are considered in hub supply & demand
Hilco / Bellwether	End user consumer with significant later phase demand supporting overall hub development; deferment of project development could lead to a demand deficit in later phases

NEPA, EIS, and Permitting | $MACH_2$ is currently updating the Individual Environmental Considerations Summary and permitting summary for each project to reflect recent changes to permitting requirements and processes. This includes last week's Supreme Court Sackett v. EPA decision, which significantly reduced jurisdiction of Clean Water Act (while few $MACH_2$ projects required Section 404 permits from the Army Corps, this number will be reduced further due to Sackett); the passage of Fiscal Responsibility Act (debt ceiling legislation), which significantly shortened NEPA permitting deadlines, established EIS page limits, and requires a lead agency to oversee EIS development (e.g. DOE); and several recently proposed EPA regulations under the Clean Air Act (could impact Area Source permitting requirements of PGW SMR w/ RNG and CCUS project). Our detailed Integrated Project Schedule (IPS) provided in the application (Figure 22: IPS – Critical Path) includes publication of Draft PEIS and public comment period on line 53 & 54 (this data was hidden in summary data provided in Table 14 due to space constraints, but an IPS filtered for regulatory & permitting activities can be found at this weblink).

Despite these changes to permitting process, we believe it is even more important to fully engage existing community advisory entities of project partners and stand-up proposed Community Outreach and Investment Committee early in project development process. While there is potential for lawsuits when developing any large industrial, pipeline, or energy project, $MACH_2$ is minimizing this risk by prioritizing projects on existing industrial sites and rights-of-way to avoid new ecological impacts, and by proactively addressing community concerns. We are also working to engage communities, environmental justice entities, and environmental NGOs collaboratively to maximize health & economic benefits of significantly reducing criteria pollutants and greenhouse gases, and increasing local employment opportunities, as $MACH_2$ accelerates region's transition from fossil fuel-based industry & transport to green & pink H_2.

For development of the Programmatic EIS, a comprehensive environmental considerations summary and permit screening for each project will be finalized during Phase I using preliminary permitting classification provided in Table 16 of application (and reflecting recent changes to permitting landscape). $MACH_2$ will review all component projects in Phase I, classify them by type for NEPA, and create a matrix of permitting requirements & deliverables by project type, size, location, and jurisdiction. This screening process provides a technical basis for tiering of detailed environmental review as part of the NEPA process, while also enumerating individual requirements for various project components (i.e. similar projects across states may require distinct sets of permits & deliverables, e.g., stormwater requirements). The $MACH_2$ PEIS approach become more detail oriented through this tiering process, which will allow for prioritization of various components with distinct development schedules, levels of completeness, and input & adjustments from community engagement. This approach provides flexibility and efficiency to ensure rapid completion of environmental reviews that are/have been initiated during early project screening and are carried forward throughout the NEPA process. $MACH_2$ is highly confident all NEPA and other permitting requirements will be fulfilled expeditiously given significant previous ecological analysis of the region, permitting expertise of the $MACH_2$ partners & staff, and community support for transitioning away from fossil fuels.

To ensure long-term CBP connectivity & integration with project activities, $MACH_2$ has dedicated leadership positions including exec. level DEIA & CBP roles, a full outreach team, and supporting board & project level committees.

Management Team and Project Planners | Individuals from our interim leadership team are expected to continue in permanent capacity, ensuring leadership continuity & certainty. Recognizing talent constraints, $MACH_2$ has permanently secured sought-after expertise:

Operational expertise	Marty Wade (CEO), Manny Citron (Chief of Staff, Philadelphia Dept. of Labor), Dora Cheatham (Community Outreach) & $MACH_2$ partners bring deep development, delivery, operational exp.
Energy technical	Joe Colella; 20+ yrs in energy pipeline infrastructure & terminals; former executive at Buckeye, Sunoco Logistics. George Murphy; 40+ yrs in waterborne supply & distribution; former Sunoco

Academic	Dr. Yushan Yan is the Henry B. DuPont Chair in Chemical & Biomolecular Engineering at University of Delaware with 300+ publications & 25+ issued patents. In 2022, he launched the Center for Clean H_2 at the University of Delaware in partnership with Chemours, Plug Power and the National Renewable Laboratory, and is the Center's Founding Director.
H_2 tech. innovation	Core $MACH_2$ partners including Versogen, sHYp, and Holtec are leading technical innovators and will provide technology innovation expertise to support hub development
Workforce development	Jim Snell; Business Manager of United Association of Plumbers and Pipefitters, Steamfitters Local # 420; Vice Chair of the Building & Construction Trades of Philadelphia, AFL-CIO
H_2 climate policy	Collin O'Mara; CEO of National Wildlife Federation (largest US conservation org.), and former head of Delaware's Dept. of Natural Resources and Environmental Control; deep expertise in H_2 and climate solutions; helped develop & pass Energy Act of 2020, IIJA, IRA.

$MACH_2$ is building a candidate pipeline and upon funding notice, will immediately onboard critical staff and hire a recruiting firm to accelerate and build a diverse leadership team.

Community Benefits Plan | $MACH_2$ will establish a Community Outreach and Investment Committee (COIC) populated by DAC representatives within $MACH_2$ and adjacent fence-line communities, e.g., Cheyney University, the nation's first HBCU, L.E.E.P. Delaware, NAACP of Gloucester County. This COIC is responsible for shaping community outreach programs, ensuring effectiveness of programs, and reviewing performance & outcomes. The committee will engage directly with $MACH_2$ executive leadership. $MACH_2$ will also establish a Monitoring, Evaluation and Learning (MEL) Working Group to focus on supporting local community efforts at each $MACH_2$ project site. MEL will be responsible for ensuring effectiveness of local outreach and engagement. Collectively, the COIC and MEL embed DAC representation in decision making at exec. level and ensure local programs effectively capture community perspectives.

Investing in America's Workforce | $MACH_2$ uses a multi-faceted approach to IAW integrating work of COIC and MEL working group. The first part of this approach is commitment from regional Workforce Development Boards (WDBs) to serve as $MACH_2$ anchor partners for community college training, pre-apprenticeships such as DE P2A, NJ P2A, and CTE/Pathways programming like the School District of Philadelphia Solar Futures. $MACH_2$ has committed \$13.85M to WDBs, paired with \$2.50M local funds for a total \$16.35M to workforce planning.

Organization	$MACH_2$ Investment	Workforce Info & Oppty	Good Jobs Challenge	Total $ available
Philadelphia Works, PA	$4.80 M	$0.50 M	$1.5 M	$6.80 M
Delaware WDB, DE	$4.65 M	$0.25 M	-	$4.90 M
Gloucester WDB, NJ	$4.40 M	$0.25 M	-	$4.65 M

HBCU and MSI Participants in $MACH_2$ Workforce Development Programs		
Cheyney University	Delaware State University	Passaic County Community College
Middlesex College	Community College of Philadelphia	Raritan Valley Community College
Essex County College	Atlantic Cape Community College	Union College of Union County
	Bergen Community College	Hudson County Community College

WDBs will support workforce diversity in two ways: US DOL federally registered & certified union apprenticeship & pre-apprenticeship programs such as the Samuel Staten Sr Pre-Apprenticeship Program (based in PA), Delaware Pathways to Apprenticeship, New Jersey Pathways to Apprenticeship, and Palm BUILT-RITE (regional). These registered apprenticeships use standardized curriculum and are typically equivalent to college credits at no or de minimis cost to participant. They will ensure a pipeline of diverse candidates eligible

for family-sustaining union jobs in our region. Additionally, WDBs will engage with Collegiate Consortium for Workforce Economic Development (CCWED) and the New Jersey Council of County Colleges (NJCCC) to develop and deliver targeted, on-demand, training for certificated programs and stackable credentials. CCWED and NJCCC are regional umbrella organizations for community colleges including nine community colleges identified as MSIs. These connections allow $MACH_2$ to recruit diverse candidates from students at local MSIs.

DEIA, EJ and J40 | $MACH_2$ completed a preliminary workforce gap analysis to support Justice40 requirements and identified non-white, Black, women, and economically disadvantaged groups as most underrepresented in high quality careers. The table details workforce participation required to achieve demographic parity within $MACH_2$ footprint (demographic parity per Site Adjacent Consensus data). Today, exact data linking worker demographic to job category is not publicly available for $MACH_2$ or project partners as a whole; however, the $MACH_2$ team has identified proxy data[1] which can be used to estimate the workforce gap.

Workforce	Demographic Parity	Proxy Data[1]	Potential Gap
Women	51.1%	2.1%	49.0%
Non-white	59.3%	27.3%	32.0%
Black	38.8%	16.6%	22.2%
Economically disadvantaged	46.6%	NA	

To engage, develop, and recruit underrepresented groups, $MACH_2$ will, in addition to our commitment to apprenticeship / pre-apprenticeship and, certificated / stackable credential programs detailed above, deploy a combination of technical and professional development programs in partnership with four universities within our footprint. These programs target overcoming barriers in higher-ed to entry-level and professional careers for underrepresented groups. $MACH_2$ is committing $10 million to technical and professional development initiatives.

$MACH_2$ investment	Development program
University of Delaware ($4.5M)	**Higher education |** 4+1 and standalone Masters degree in electrochemical engineering; this new program will enable H_2 technology training at the graduate level
Cheyney University ($1.5M)	**Technical training |** Hands-on H_2 safety training program & certification for mid-Atlantic region, developed w/ American Institute of Chemical Engineers
UPenn ($2.0M)	**Higher education |** H_2 technology training; undergrad & PhD level
Rowan University ($2.0M)	**Technical training |** Hands-on engineering clinic on wind-to H_2 processing to recruit for offshore wind projs. underway in NJ & DE. To advance entry level & underrepresentation, Rowan University is proposing an online masters in H_2 Processing & Sys. Engineering stackable w/ a 2yr Process Technology degree offered by Rowan College of South Jersey

In addition to Cheyney University, HBCUs Lincoln University and Delaware State University, are located within the $MACH_2$ footprint and are targeted discrete commitments as regional H_2 projects begin to go live. We will work with our lead project partner for higher education, the University of Delaware, to integrate Lincoln University and Delaware State University into our higher-ed pipeline as future collaboration opportunities materialize. All partner schools have detailed DEIA programs and committed & equipped to support $MACH_2$ grow a diverse workforce and advance underrepresented groups across mid-Atlantic region. Additionally, credential collaboration between Rowan University & Rowan College, will promote a model of industry-directed, stackable credentials to showcase pathways to higher paying jobs and multiple entry & exit points for learners along the H2 education continuum.

[1] City of Philadelphia Economic Opportunity Plan Employment Composition Analysis for FY 2021, published in July 2022; starting point & proxy for $MACH_2$ hub; Philadelphia (1.5M population) is largest population center in $MACH_2$

Instructions and Summary

OMB Control Number: 1910-5162
Expiration Date: 04/30/2025

Award Number:
Award Recipient: Mid-Atlantic Clean Hydrogen Hub, Inc.

Date of Submission: 5-Apr-23
Form submitted by: Mid-Atlantic Clean Hydrogen Hub, Inc.
(May be award recipient or sub-recipient)

Please read the instructions on each worksheet tab before starting. If you have any questions, please ask your EERE contact!
Do not modify this template or any cells or formulas!

1. If using this form for award application, negotiation, or budget revision, fill out the blank white cells in workbook tabs a. through j. with total project costs.
2. Blue colored cells contain instructions, headers, or summary calculations and should not be modified. Only blank white cells should be populated.
3. Enter detailed support for the project costs identified for each Category line item within each worksheet tab to autopopulate the summary tab.
4. The total budget presented on tabs a. through i. must include both Federal (DOE) and Non-Federal (cost share) portions.
5. All costs incurred by the preparer's sub-recipients, contractors, and Federal Research and Development Centers (FFRDCs), should be entered only in section f. Contractual. All other sections are for the costs of the preparer only.
6. Ensure all entered costs are allowable, allocable, and reasonable in accordance with the administrative requirements prescribed in 2 CFR 200, and the applicable cost principles for each entity type: FAR Part 31 for For-Profit entities; and 2 CFR Part 200 Subpart E - Cost Principles for all other non-federal entities.
7. Add rows as needed throughout tabs a. through j. If rows are added, formulas/calculations may need to be adjusted by the preparer. Do not add rows to the Instructions and Summary tab. If your project contains more than five budget periods, consult your EERE contact before adding additional budget period rows or columns.
8. ALL budget period cost categories are rounded to the nearest dollar.

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

a. Personnel

INSTRUCTIONS - PLEASE READ!!!

1. List project costs solely for employees of the entity completing this form. All personnel costs for subrecipients and contractors must be included under f. Contractual.
2. All personnel should be identified by position title and not employee name. Enter the amount of time (e.g., hours or % of time) and the base hourly rate and the total direct personnel compensation will automatically calculate. Rate basis (e.g., rate negotiated for each hour worked on the project, labor distribution report, state civil service rates, etc.) must also be identified.
3. If loaded labor rates are utilized, a description of the costs the loaded rate is comprised of must be included in the Additional Explanation section below. DOE must review all components of the loaded labor rate for reasonableness and unallowable costs (e.g. fee or profit).
4. If a position and hours are attributed to multiple employees (e.g. Technician working 4000 hours) the number of employees for that position title must be identified.
5. Each budget period is rounded to the nearest dollar.

SOPO Task #	Position Title	Budget Period 1			Budget Period 2			Budget Period 3			Budget Period 4			Budget Period 5			Project Total Hours	Project Total Dollars	Rate Basis
		Time (Hrs)	Hourly Rate ($/Hr)	Total Budget Period 1	Time (Hrs)	Hourly Rate ($/Hr)	Total Budget Period 2	Time (Hrs)	Hourly Rate ($/Hr)	Total Budget Period 3	Time (Hrs)	Hourly Rate ($/Hr)	Total Budget Period 4	Time (Hrs)	Hourly Rate ($/Hr)	Total Budget Period 5			
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	TOTAL PERSONNEL	[redacted]		[redacted]			[redacted]			[redacted]			[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	

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b. Fringe Benefits

INSTRUCTIONS - PLEASE READ!!!
1. Fill out the table below by position title. If all employees receive the same fringe benefits, you can show "Total Personnel" in the Labor Type column instead of listing out all position titles.
2. The rates and how they are applied should not be averaged to get one fringe cost percentage. Complex calculations should be described/provided in the Additional Explanation section below.
3. The fringe benefit rates should be applied to all positions, regardless of whether those funds will be supported by Federal Share or Recipient Cost Share.
4. Each budget period is rounded to the nearest dollar.

Labor Type	Budget Period 1			Budget Period 2			Budget Period 3			Budget Period 4			Budget Period 5			Total Project
	Personnel Costs	Rate	Total	Personnel Costs	Rate	Total	Personnel Costs	Rate	Total	Personnel Costs	Rate	Total	Personnel Costs	Rate	Total	
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A federally approved fringe benefit rate agreement, or a proposed rate supported and agreed upon by DOE for estimating purposes is required at the time of award negotiation if reimbursement for fringe benefits is requested. Please check (X) one of the options below and provide the requested information if not previously submitted.

______ A fringe benefit rate has been negotiated with, or approved by, a federal government agency. A copy of the latest rate agreement is/was included with the project application.*

__X__ There is not a current federally approved rate agreement negotiated and available.**

*Unless the organization has submitted an indirect rate proposal which encompasses the fringe pool of costs, please provide the organization's benefit package and/or a list of the components/elements that comprise the fringe pool and the cost or percentage of each component/element allocated to the labor costs identified in the Budget Justification.

**When this option is checked, the entity preparing this form shall submit an indirect rate proposal in the format provided in the Sample Rate Proposal at https://www.energy.gov/eere/funding/downloads/sample-indirect-rate-proposal-and-profit-compliance-audit, or a format that provides the same level of information and which will support the rates being proposed for use in the performance of the proposed project.

Additional Explanation (as necessary): Please use this box (or an attachment) to list the elements that comprise your fringe benefits and how they are applied to your base (e.g. Personnel) to arrive at your fringe benefit rate.

Fringe cost is based on the average market-rate benefits percentage for nonprofit organizations. If selected for award, Mid-Atlantic Clean Hydrogen Hub, Inc. will submit a formal indirect rate proposal at the time of award negotiation, as specified above.

c. Travel

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION [redacted]

SOPO Task #	Purpose of Travel	Depart From	Destination	No. of Days	No. of Travelers	Lodging per Traveler	Flight per Traveler	Vehicle per Traveler	Per Diem Per Traveler	Cost per Trip	Basis for Estimating Costs
	Domestic Travel				Budget Period 1						
1	EXAMPLE!!! Visit to PV manufacturer			2	2	$250	$500	$100	$80	$1,860	Current GSA rates
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]										
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Budget Period 1 Total									[redacted]	
	[redacted]				Budget Period 2						
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]										
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Budget Period 2 Total									[redacted]	
	[redacted]				Budget Period 3						
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]										
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Budget Period 3 Total									[redacted]	
	[redacted]				Budget Period 4						
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]										
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Budget Period 4 Total									[redacted]	
	[redacted]				Budget Period 5						
										[redacted]	
										[redacted]	
										[redacted]	
										[redacted]	
	[redacted]										
										[redacted]	
	Budget Period 5 Total									[redacted]	
	TOTAL TRAVEL									[redacted]	

[redacted]

[redacted]

[redacted]

[redacted]

SOPO Task #	Equipment Item	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need
				[redacted]		
3,4,5	**EXAMPLE!!!** Thermal shock chamber	2	$70,000	$140,000	Contractor Quote - Attached	Reliability testing of PV modules- Task 4.3
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
				[redacted]		
				[redacted]		
				[redacted]		
	Budget Period 1 Total			[redacted]		
				[redacted]		
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
				[redacted]		
				[redacted]		
				[redacted]		
	Budget Period 2 Total			[redacted]		
				[redacted]		
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
				[redacted]		
				[redacted]		
				[redacted]		
	Budget Period 3 Total			[redacted]		
				[redacted]		
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
				[redacted]		
				[redacted]		
				[redacted]		
	Budget Period 4 Total			[redacted]		
				[redacted]		
				[redacted]		
				[redacted]		
				[redacted]		
				[redacted]		
				[redacted]		
				[redacted]		
	Budget Period 5 Total			[redacted]		
	[redacted] **EQUIPMENT**			[redacted]		

[redacted]

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION
[redacted]

e. Supplies

[redacted]

SOPO Task #	General Category of Supplies	Qty	Unit Cost	Total Cost	Basis of Cost	Justification of need
			Budget Period 1			
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
				[redacted]		
	Budget Period 1 Total			[redacted]		
			Budget Period 2			
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
				[redacted]		
	Budget Period 2 Total			[redacted]		
			Budget Period 3			
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
				[redacted]		
	Budget Period 3 Total			[redacted]		
			Budget Period 4			
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
				[redacted]		
	Budget Period 4 Total			[redacted]		
			Budget Period 5			
				[redacted]		
	Budget Period 5 Total			[redacted]		
	TOTAL SUPPLIES			[redacted]		

[redacted]

f. Contractual

INSTRUCTIONS - PLEASE READ!!!

1. The entity completing this form must provide all costs related to sub-recipients, contractors, and FFRDC partners in the applicable boxes below.
2. Sub-recipients (partners, sub-awardees): Subrecipients shall submit a Budget Justification describing all project costs and calculations when their total proposed budget exceeds either (1) $250,000 or (2) 25% of total award costs. These sub-recipient forms may be completed by either the sub-recipients themselves or by the preparer of this form. The budget totals on the sub-recipient's forms must match the sub-recipient entries below. A subrecipient is a legal entity to which a subaward is made, who has performance measured against whether the objectives of the Federal program are met, is responsible for programmatic decision making, must adhere to applicable Federal program compliance requirements, and uses the Federal funds to carry out a program of the organization. All characteristics may not be present and judgment must be used to determine subrecipient vs. vendor status.
3. Contractors (including contractors): List all contractors supplying commercial supplies or services used to support the project. For each Contractor cost with total project costs of $250,000 or more, a Contractor quote must be provided. A contractor is a legal entity contracted to provide goods and services within normal business operations, provides similar goods or services to many different purchasers, operates in a competitive environment, provides goods or services that are ancillary to the operation of the Federal program, and is not subject to compliance requirements of the Federal program. All characteristics may not be present and judgment must be used to determine subrecipient vs. contractor status.
4. Federal Funded Research and Development Centers (FFRDCs): FFRDCs must submit a signed Field Work Proposal during award application. The award recipient may allow the FFRDC to provide this information directly to DOE, however project costs must also be provided below.
5. Each budget period is rounded to the nearest dollar.

SOPO Task #	Sub-Recipient Name/Organization	Sub-Recipient Unique Entity Identifier (UEI)	Purpose and Basis of Cost	Budget Period 1	Budget Period 2	Budget Period 3	Budget Period 4	Budget Period 5	Project Total
BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION [redacted]									
			Sub-total	$103,061,516	$524,139,668	$1,740,968,208	$409,535,594	$0	$2,777,704,986

SOPO Task #	Contractor Name/Organization	Purpose and Basis of Cost	Budget Period 1	Budget Period 2	Budget Period 3	Budget Period 4	Budget Period 5	Project Total
BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION [redacted]								
BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION [redacted]								

SOPO Task #	FFRDC Name/Organization	Purpose and Basis of Cost	Budget Period 1	Budget Period 2	Budget Period 3	Budget Period 4	Budget Period 5	Project Total
BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION [redacted]								
BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION [redacted]								

Additional Explanation (as needed): As required by DOE as indicated in the application FAQs, if selected for award, all subrecipients will register for, or update, and provide a valid UEI number prior to MACH2, Inc. making a subaward to the subrecipient.

Community Benefits costs are included as: University of Delaware Subrecipient (lead academic partner), and Contractor services where indicated above, inclusive of public meetings and events, as well as in dedicated Personnel (see Tab a).

See subrecipient budget worksheets, Technical Volume, and TEA/LCA for more detailed assumptions and justifications related to subrecipient industry partner costs. Unless specified above in the SOPO column, all Phase 1 permitting, NEPA, and regulatory tasks for subrecipient projects will be completed as needed per the IPS.

g. Construction

PLEASE READ!!!

1. Construction, for the purpose of budgeting, is defined as all types of work done on a particular building, including erecting, altering, or remodeling. Construction conducted by the award recipient is entered on this page. Any construction work that is performed by a contractor or subrecipient should be entered under f. Contractual.

2. List all proposed construction below, providing a basis of cost such as engineering estimates, prior construction, etc., and briefly justify its need as it applies to the Statement of Project Objectives.

3. Each budget period is rounded to the nearest dollar.

Overall description of construction activities: Example Only!!! - Build wind turbine platform

SOPO Task #	General Description	Cost	Basis of Cost	Justification of need

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Additional Explanation (as needed):

h. Other Direct Costs

INSTRUCTIONS - PLEASE READ!!!

1. Other direct costs are direct cost items required for the project which do not fit clearly into other categories. These direct costs must not be included in the indirect costs (for which the indirect rate is being applied for this project). Examples are: tuition, printing costs, etc. which can be directly charged to the project and are not duplicated in indirect costs (overhead costs).

2. Basis of cost are items such as vendor quotes, prior purchases of similar or like items, published price list, etc.

3. Each budget period is rounded to the nearest dollar.

SOPO Task #	General Description and SOPO Task #	Cost	Basis of Cost	Justification of need
		Budget Period 1		

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

	Budget Period 4 Total	$412,180		

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Additional Explanation (as needed): Co-working rental space assumes +6% escalation starting in Phase 3.

i. Indirect Costs

INSTRUCTIONS - PLEASE READ!!!
1. Fill out the table below to indicate how your indirect costs are calculated. Use the box below to provide additional explanation regarding your indirect rate calculation.
2. The rates and how they are applied should not be averaged to get one indirect cost percentage. Complex calculations or rates that do not do not correspond to the below categories should be described/provided in the Additional Explanation section below. If questions exist, consult with your DOE contact before filling out this section.
3. The indirect rate should be applied to both the Federal Share and Recipient Cost Share.
4. NOTE: A Recipient who elects to employ the 10% de minimis Indirect Cost rate **cannot claim resulting costs as a Cost Share contribution, nor can the Recipient claim "unrecovered indirect costs" as a Cost Share contribution.** Neither of these costs can be reflected as actual indirect cost rates realized by the organization, and therefore are not verifiable in the Recipient records as required by Federal Regulation (§200.306(b)(1)).
5. Each budget period is rounded to the nearest dollar.

	Budget Period 1	Budget Period 2	Budget Period 3	Budget Period 4	Budget Period 5	Total	Explanation of BASE

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

A federally approved indirect rate agreement, or rate proposed (supported and agreed upon by DOE for estimating purposes) is required if reimbursement of indirect costs is requested. Please check (X) one of the options below and provide the requested information if it has not already been provided as requested, or has changed.

______ **An indirect rate has been approved or negotiated with a federal government agency. A copy of the latest rate agreement is included with this application and will be provided electronically to the Contracting Officer for this project.**
______ **The organization does not have a current, federally approved indirect cost rate agreement and has provided an indirect rate proposal in support of the proposed costs.**
______ **This organization has elected to apply a 10% de minimis rate in accordance with 2 CFR 200.414(f).**

Provide an explanation of how your indirect cost rate was applied.

*Additional Explanation (as needed): *IMPORTANT: Please use this box (or an attachment) to further explain how your total indirect costs were calculated. If the total indirect costs are a cumulative amount of more than one calculation or rate application, the explanation and calculations should identify all rates used, along with the base they were applied to (and how the base was derived), and a total for each (along with grand total).*

Cost Share

PLEASE READ!!!

1. A detailed presentation of the cash or cash value of all cost share proposed must be provided in the table below. All items in the chart below must be identified within the applicable cost category tabs a. through i. in addition to the detailed presentation of the cash or cash value of all cost share proposed provided in the table below. Identify the source organization & amount of each cost share item proposed in the award.

2. Cash Cost Share - encompasses all contributions to the project made by the recipient, subrecipient, or third party (an entity that does not have a role in performing the scope of work) for costs incurred and paid for during the project. This includes when an organization pays for personnel, supplies, equipment, etc. for their own company with organizational resources. If the item or service is reimbursed for, it is cash cost share. All cost share items must be necessary to the performance of the project. **Contractors may not provide cost share.** Any partial donation of goods or services is considered a discount and is not allowable.

3. In Kind Cost Share - encompasses all contributions to the project made by the recipient, subrecipient, or third party (an entity that does not have a role in performing the scope of work) where a value of the contribution can be readily determined, verified and justified but where no actual cash is transacted in securing the good or service comprising the contribution. In Kind cost share items include volunteer personnel hours, the donation of space or use of equipment, etc. The cash value and calculations thereof for all In Kind cost share items must be justified and explained in the Cost Share Item section below. All cost share items must be necessary to the performance of the project. If questions exist, consult your DOE contact before filling out In Kind cost share in this section. Contractors may not provide cost share. Any partial donation of goods or services is considered a discount and is not allowable.

4. Funds from other Federal sources MAY NOT be counted as cost share. This prohibition includes FFRDC sub-recipients. Non-Federal sources include any source not originally derived from Federal funds. Cost sharing commitment letters from subrecipients and third parties must be provided with the original application.

5. Fee or profit, including foregone fee or profit, **are not allowable** as project costs (including cost share) under any resulting award. The project may only incur those costs that are allowable and allocable to the project (including cost share) as determined in accordance with the applicable cost principles prescribed in FAR Part 31 for For-Profit entities and 2 CFR Part 200 Subpart E - Cost Principles for all other non-federal entities.

6. NOTE: A Recipient who elects to employ the 10% de minimis Indirect Cost rate **cannot claim the resulting indirect costs as a Cost Share contribution.**

7. NOTE: A Recipient **cannot claim "unrecovered indirect costs"** as a Cost Share contribution, **without prior approval.**

8. Each budget period is rounded to the nearest dollar.

Organization/Source	Type (Cash or	Cost Share Item	Budget	Budget	Budget	Budget Period 4	Budget	Total Project

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Applicant Name: Mid-Atlantic Clean Hydrogen Hub, Award Number: 0

Budget Information - Non Construction Programs

OMB Approval No. 0348-0044

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

Previous Edition Usable

SF-424A (Rev. 4-92)
Prescribed by OMB Circular A-102

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION [redacted]

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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

[redacted]

J40 BENEFITS

GOAL IMPLEMENTATION STRATEGIES AND MEASUREMENT

1 Decreased Energy Burden | Healthy Home Retrofit

Target Outcome: Annual average energy burden: DAC = Natl. Avg.
Metrics: Household Energy Burden: average annual housing energy costs / average annual household income | Energy saved [MMBTU or MWh] or reduction in fuel [GGe] by DACs
Data Source: DoE datasets, recipient home data reporting

2 Decreased Environmental Exposure & Burdens | Bus retrofit | Decreased Truck Emissions | Legacy Superfund & Toxic Sites Remediation | Retrofit of Industrial Operations

Target Outcome: Air quality rates = background rate for the region; Water Quality index < 50 percentile. At least one facility of each hazard category has been fully remediated.
Metrics: PM2.5 | Diesel Particulate Matter | EJ index for Air Toxic & Cancer Risk | Water Discharge, EJ Index for Indicator for major direct dischargers to water | EJ Index for Proximity to Treatment Storage and Disposal (TSDF) facilities | EJ Index for Proximity to Risk Management Plan (RMP) facilities, to National Priorities List (NPL) sites
Data Source: EPA & State Environmental Agencies reporting; Non-profit Citizen Science Partners | P.A.R. research as a part of Community Engagement

3 Increased Parity in Clean Energy Technology Access and Adoption | Healthy Home Retrofit | Micro-Grid

Target Outcome: Clean Energy Technology Adoption rates: Natl Avg = Project DAC
Metrics: Clean energy resource [MWh] adopted in DACs
Data Source: Ground level survey, partnered with home retrofit non-profit

4 Increased Access to Low-Cost Capital | Energy Lending

Target Outcome: #(TBD) Registered Clean Energy Minority Businesses: before MACH2 project vs at Phase benchmarks
Metrics: Number of contracts and/or dollar value [$] awarded to businesses that are principally owned by women, minorities, disabled veterans, and/or LGBT persons
Data Source: Partner bank data and verification

5 Increased Clean Energy Enterprise Creation & Contracting for Minority Business in DACs | Local Provider Contracts | Energy Lending

Target Outcome: Each DAC has X# small business, TBD with CBOs, phase 1
Metrics: # Registered Clean Energy Minority Businesses: before MACH2 project vs at Phase benchmarks | Number of contracts and/or dollar value [$] awarded to businesses that are principally owned by women, minorities, disabled veterans, and/or LGBT persons
Data Source: Clean energy business certification agency reporting data

6 Enterprises/Disadvantaged Business Enterprises | Local Provider Contracts | Energy Lending

Target Outcome: Each DAC has X# contract-receiving small business, TBD with CBOs phase 1
Metrics: # DAC business with energy contracts: before MACH2 project vs at Phase benchmarks
Data Source: MACH2 partner reporting data, ground verification

7 Increased Clean Energy Jobs, Job Pipeline, and Job Training for Individuals | Jobs Training and Workforce Development

Target Outcome: Targets for each below determined with local workforce partners, phase 1
Metrics: Percent of total civilian jobs in the energy sector for Project Hosting Community DACS | Dollars spent [$] and/or number of participants from DACs in job training programs, apprenticeship programs, STEM education, tuition, scholarships, and recruitment | Number of hires from DACs resulting from DOE job trainings | Number of jobs created for DACs because of DOE program | Number of and/or dollar value [$] of partnerships, contracts, or training with minority serving institutions (MSIs)
Data Source: Workforce partner reporting data, ground verification

8 Increased Energy Resiliency | Energy Lending | Healthy Home Retrofit | Micro-Grid

Target Outcome: Elements deployed TBD with CBOs phase 1; MWh = natl avg by phase 4
Metrics: Number and size (MWh) of community resilience infrastructure deployed in DACs (e.g., Distributed solar plus storage, utility scale, DERs, Micro-Grids)
Data Source: Federal data from DoE, Homeland Security, FEMA

9 Increased Energy Democracy | Local Provider Contracts | Micro-Grid | MACH2 Project Governance

Target Outcome: Targets for each below determined with local energy democracy advocates, phase 1
Metrics: # seats on MACH2 working groups & advisory committees held by DAC representing organizations | % of generation and grid under local coop control | Dollar value [$] and number of clean energy assets owned by DACs members | Number of tools, trainings for datasets/tools, people trained and/or hours dedicated to dataset/tool and technical assistance and knowledge transfer efforts to DACs
Data Source: MACH2 annual report data

Figure 9 J40 Goal Implementation Strategies & Measurement

BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

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BUSINESS SENSITIVE INFORMATION OR PERSONAL CONTACT INFORMATION

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