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# Direct Air Capture and Carbon Removal Technology Program Overview to Decarbonization Research Consortium

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# Direct Air Capture & Carbon Removal Technology Program

## OBJECTIVE

***Develop and combine Direct Air Capture (DAC) and Direct Ocean Capture (DOC) technologies with fuel synthesis (FS) technologies and material synthesis technologies to provide fuel and material producing options for forward base deployment***

## ONGOING INITIATIVES

1. ***Development of lightweight, compact, efficient, cost-effective, deployable technologies for direct ocean (DOC) and direct air capture (DAC) of environmental carbon.***
2. ***Scalable thermochemical, biological, and electrochemical reaction pathways to liquid fuels, lubricants, and materials.***
3. ***Modeling and simulation of reaction pathways, technology scaling, and environmental and mission impacts.***

## WHY THIS IS IMPORTANT

1. ***Enhancing DOC and DAC capabilities to fieldable technologies is becoming increasingly important for future operational implementation.***
2. ***Next-generation carbon conversion technologies are important for operational endurance and sustainability.***
3. ***DAC and DOC Technology program supports Navy Climate Action 2030, "net zero" carbon emissions goals.***

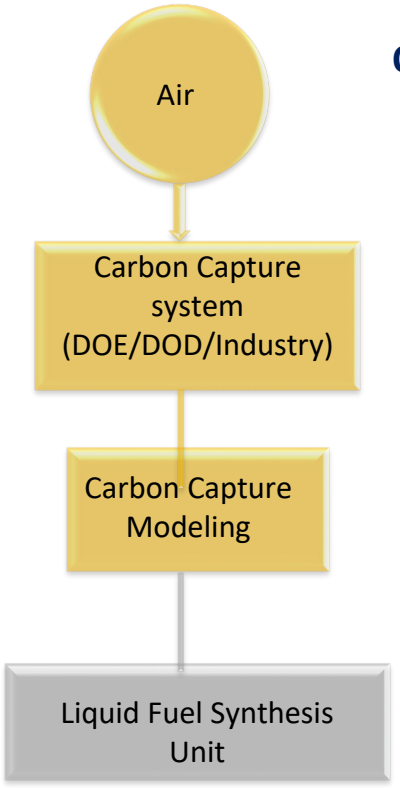
*Leverage DoD, DOE, DoN, ARPA-E, academia, and industry collaborations and accomplishments to date to support the research, development, demonstration, and transition of the technologies to commercial and military partners*

## TRANSITION OPPORTUNITIES

1. ***DOC and DAC science and technology developments align with NPES-TDR.***
2. ***Fuels, lubricants, and materials from environmental carbon align with DoN Installation Energy Resilience Strategy, Naval R&D Framework, NPES-TDR***
3. ***Carbon-neutral fuel that meets MIL-DTL-5624W.***

# Direct Air Capture Technologies (DAC)

**Direct Air Capture**




Partnered with the Department of Energy (DOE) to identify and advance DAC research initiatives most relevant to DoD energy security

## ONGOING INITIATIVES

- Combine atmospheric water extraction and $CO_2$ in a Hybrid Direct Air Capture system (HDAC) that will be manufactured and field tested
- Developing and scaling coating strategies for enhanced $CO_2$ uptake and water uptake
- Demonstration of 30 tonnes/year of $CO_2$ and 1000 L/day $H_2O$
- Scale process to 300 tonnes/year of $CO_2$ and 2000 to 3000 tonnes/year $H_2O$
- Fully integrate DAC to fuel synthesis process for demonstration
- DAC testing of materials in integrated field units and advancing energy recovery to reduce the cost of DAC

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# Direct Ocean Capture Technologies (DOC)

## What if you could make designer fuel when and where you need it?



## In-theater fuel production is a "Game Changing Proposition"

- **Fuel at point of use translates into "Freedom of Action" (VADM Cullom, USNA, Ret.)**
  - Reduce logistic tails and their vulnerabilities
  - Stabilize future naval fuel cost and availability
  - Provide fixed, highly predictable costs for long-term budget planning
  - Minimize dependence on increasingly expensive and limited fossil fuels

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# Direct Ocean Capture Technologies (DOC)

## Where could you get the components to make fuel in the "Area of Operations" (AOO)?

**$H_2O$**
**(oceans or rivers)**

**Electricity**
**(nuclear, wind, solar, wave)**

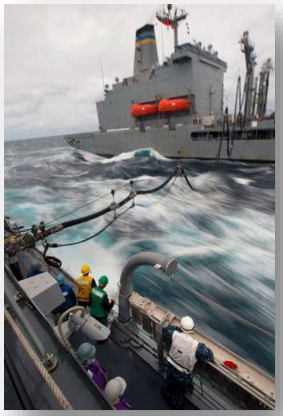
**Designer Fuels**
**(CNG/LNG/JP5/F76)**

- Carbon dioxide
- Hydrogen
- Electrical source is an operational consideration
- Next level decision after technology is developed and demonstrated

# Direct Ocean Capture Technologies (DOC)

## Scientific and Technical Challenges

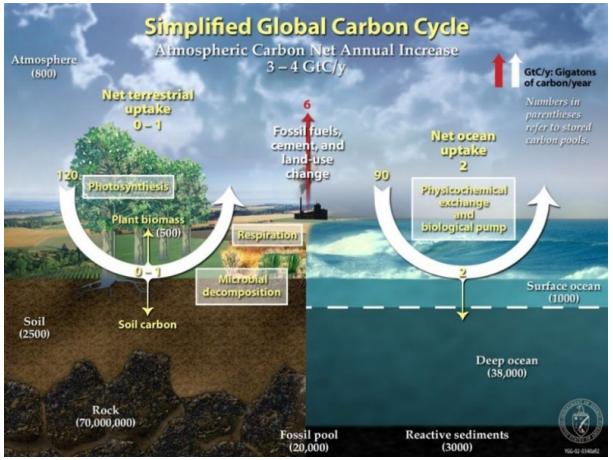
- Capturing large quantities of carbon dioxide and hydrogen quickly and efficiently from seawater.
- Achieving high catalytic conversion efficiencies and selectivities of carbon dioxide plus hydrogen to designer fuel.
- Keeping both the extraction module and the fuel production plant footprints to a reasonable size and weight.



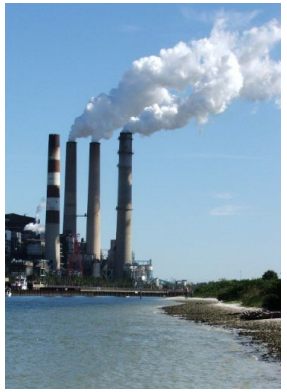
# Direct Ocean Capture Technologies (DOC)

## Why capture $CO_2$ from Seawater?

- Renewable supply of $CO_2$ and $H_2$ feedstocks in Navy marine and littoral environments ~72% of the globe.
- $CO_2$ is 140 times more concentrated in seawater than air on a (w/v) basis (100 mg/L seawater vs 0.77 mg/L air).
- $CO_2$ from seawater is 1/3 (100 mg/L) the concentration of $CO_2$ found in stack gas from coal fire power plants (296 mg/L).
- Additional electrolysis equipment for production of $H_2$ is required if $CO_2$ is capture from air.




Genomics: GTL Roadmap, U.S. Department of Energy Office of Science, August 2005



# Direct Ocean Capture Technologies (DOC)

## Pros:

No chemical additions are required - Processed seawater may be returned to source with no contamination

No additional equipment for hydrogen production required - Hydrogen produced simultaneously at the cathode

## Cons:

A relatively large volume of water must be processed - ≈ 23,000 gallons or 87,000 L (roughly a swimming pool 20 x 20 ft. square x 7 ft. deep {or 6.1 x 6.1 x 2.1 m} ) for every gallon of fuel produced

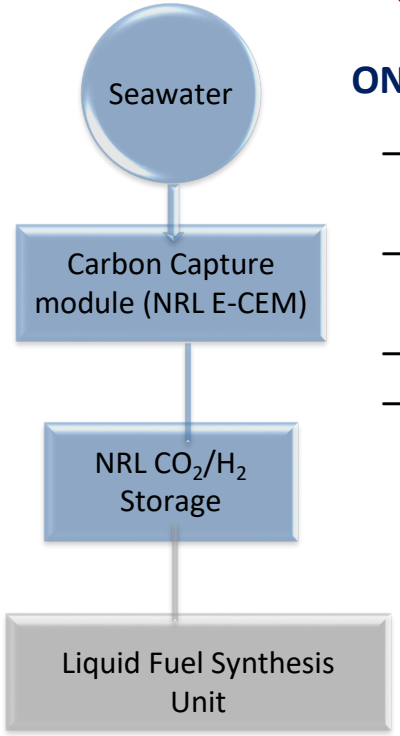
## Alternatives:

To produce 1 gallon of fuel from air - ≈ 3.2 million gallons of air must be processed

# Direct Ocean Capture Technologies (DOC)

Partnered with the industry, academia, and other government to advance DOC research initiatives most relevant to DoD energy security

**Blue Carbon Removal**




## ONGOING INITIATIVES

- Develop lighter, more efficient, scalable electrochemical approaches to capturing carbon dioxide from alkaline water sources
- Develop electrode catalyst materials that are suitable for both HER and OER
- Integrate, scale, and demonstrate DOC solutions
- Establishing a navy test facility to evaluate and demonstrate
  - DOC solutions utilizing different alkaline water sources
  - Scale and integrate DOC solutions
  - Prototype $CO_2$ utilization technologies
  - Develop and evaluate $CO_2$ recovery and purification technologies

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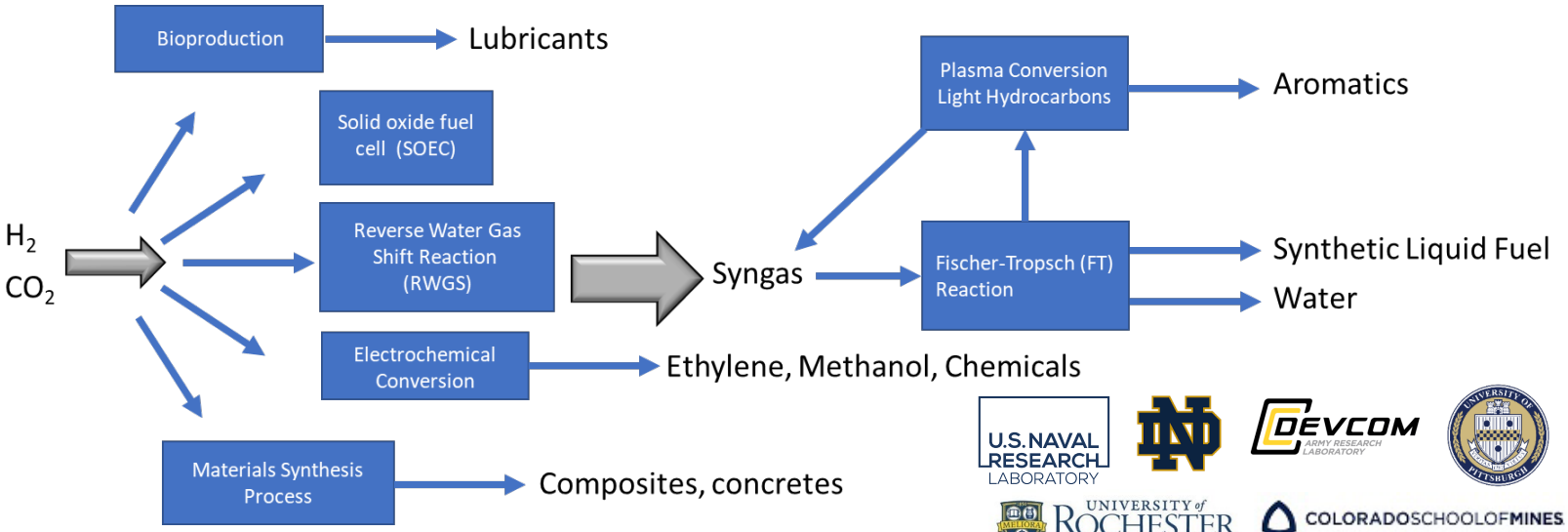
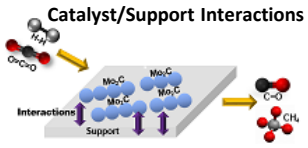
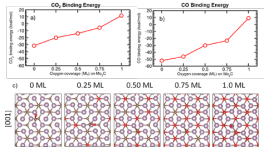
# Fuels, Chemicals, Lubricants, and Material Synthesis



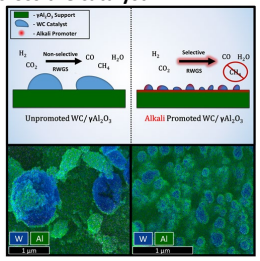

## ONGOING INITIATIVES

- Fuels, chemicals, and lubricants that meet navy specifications
- Technology development to reduce size, weight, process footprint, and enhance energy efficiencies
- Optimize catalysts and operating conditions to maximize efficiency and liquid fuel product yields to JP-5
- Lower temperature thermochemical RWGs
- SOEC for both hydrogen and syngas production
- Composite production for forward solutions



**SEM-EDS images shows the difference between localized and dispersed Tungsten (WC) regions across the catalyst**



# Direct Air Capture & Carbon Removal Technology Program

## PLANS

"Carbon Dioxide as a Source of Naval Energy and Materials-Broad Agency Announcement (BAA) that is focused directing industry and academia to specific research focus under the ONR Long Range BAA

- Develop approaches to produce sustainable aviation fuel from environmental carbon that meets or exceeds MIL-DTL-5624W without the need to blend with petroleum jet fuel.
- Develop novel approaches (SOEC, plasma) to produce syngas as the immediate for production of sustainable aviation fuel from environmental carbon
- Developing sustainable processes to convert environmental CO2 to materials and productions that can be used to enhance additive manufacturing processes
- Electrode catalyst alternatives for HER and OER reactions under environmental conditions

Mining Seawater for minerals

- Develop passive low energy intensive approaches to capture and concentrates minerals such as lithium and uranium from the ocean
- Approaches that take advantage of the water that is processed for DOC applications

The FY 2024 ONR YIP FOA was posted today on grants.gov and the ONR website. Announcement Number: N00014-23-S-F004.