Carbon Hub Webinar - Call for Proposals Fall 2021

Carbon Hub




Topic #4: Demonstrate and explain efficacy of a VACS as a soil amendment.





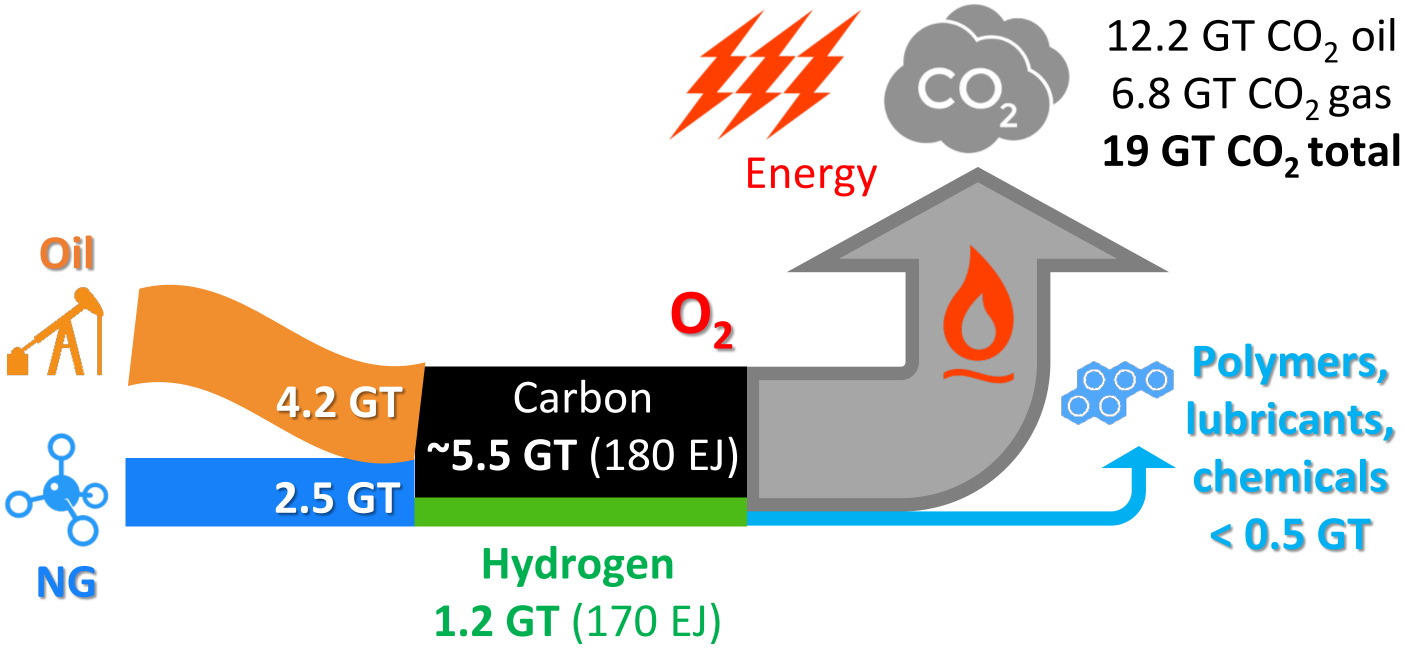

Carbon Hub Webinar - Agenda

Carbon Hub

General	❑ Introduction Carbon Hub ❑ Mission and Vision	10 min
What are we trying to solve?	❑ Topic Introduction ❑ Expert deeper dive ❑ Key deliverables ❑ What is out of scope – What are we NOT looking for ❑ Budget and timeline	30 min
Q&A	❑ Please ask us questions	15 min
Next Steps	❑ In summary – How to submit your proposal ❑ Call for Proposal Process and timeline - Some Terms & Conditions	5 min

The Carbon and Material Challenge

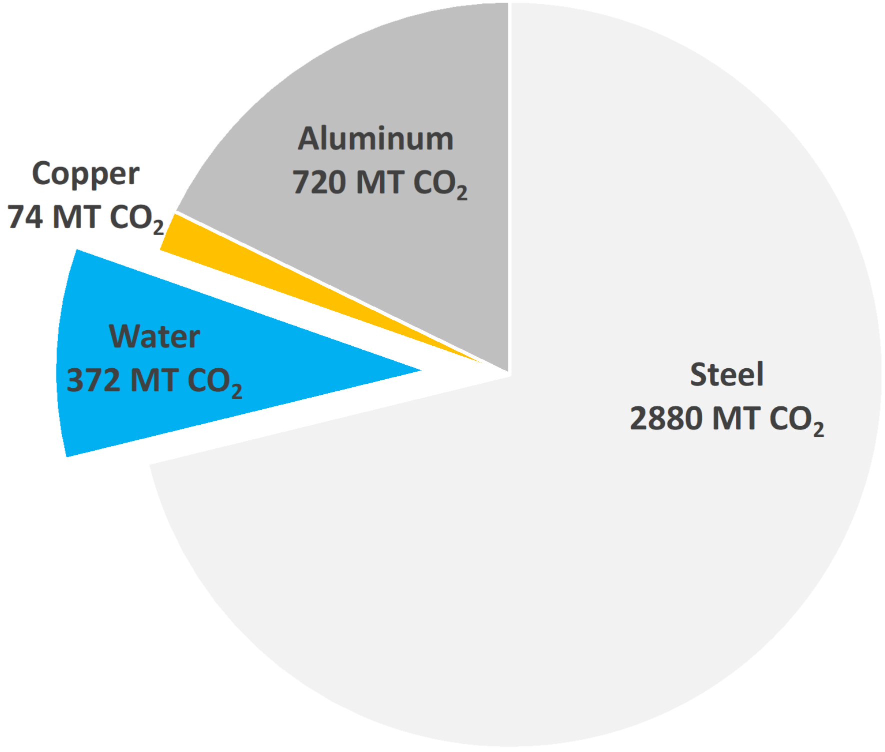
85% of world energy comes from carbon combustion



19 GT CO_2 / yr

"indicative numbers" 2017 data

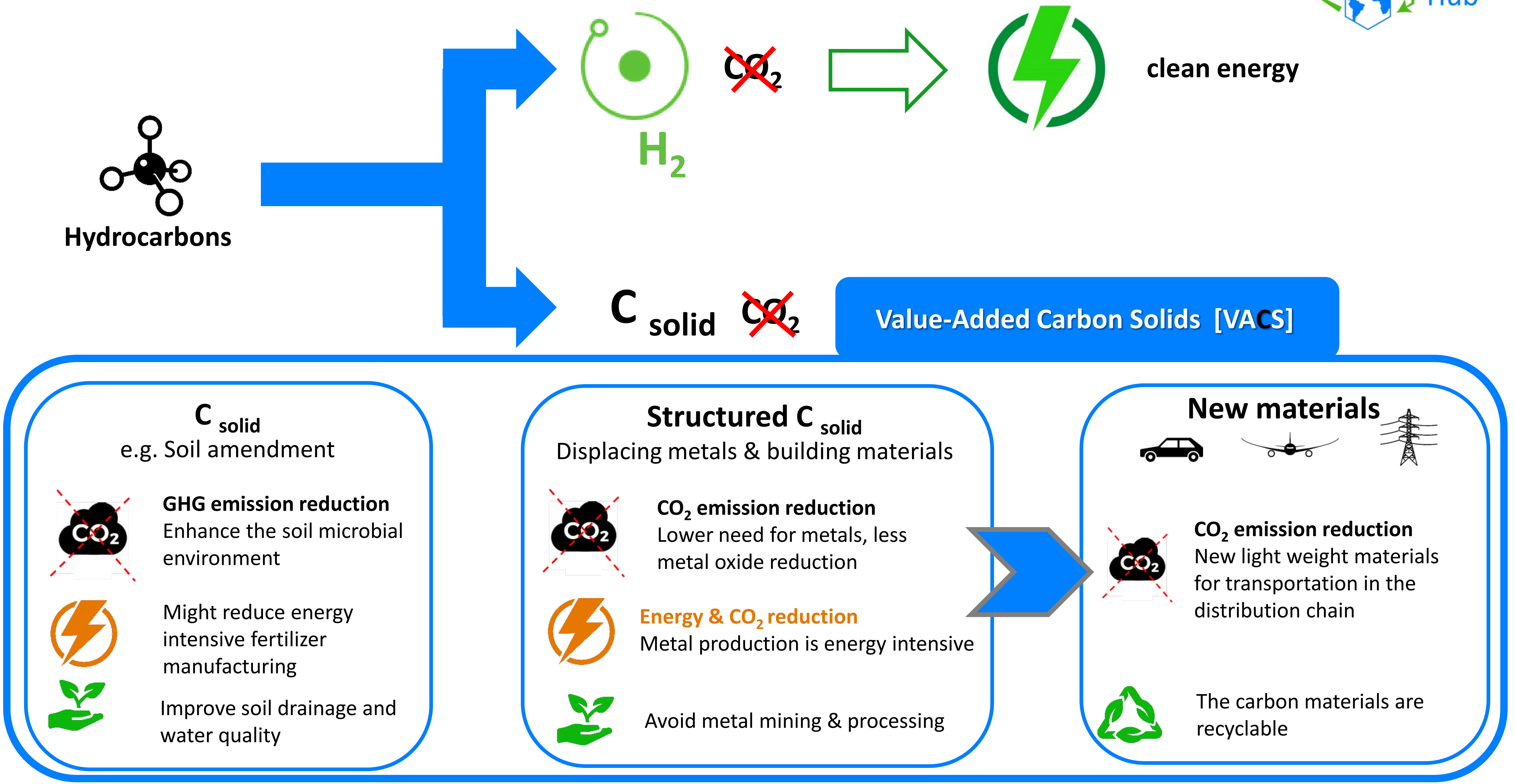
12% of world energy is used for production of steel , aluminum and copper



3.7 GT CO_2 / yr

"indicative numbers"

The Carbon Hub aims to alter the Energy – Materials Nexus



Value-Added Carbon Solids – Our definition

NG
Natural Gas
Light HC

→

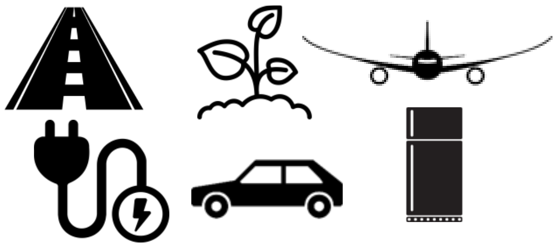
H_2 ~~CO_2~~

C **solid**

→

Application in end-products


scale value



VACS

A solid carbon material produced by splitting efficiently (e.g., by pyrolysis) methane and light hydrocarbons with concurrent production of hydrogen and no carbon dioxide emissions.

Being used pervasively (>1 MM Tons/year)

Displacing metals, traditional construction ceramics, fertilizers and other materials with high CO_2 footprints.

excluded

- Carbon black, amorphous carbons, graphite
- Polymers
- Solid carbon whose only value is a CO_2 emission avoidance or that will be oxidized in other processes (e.g., metallurgical coke)

included

- Carbon materials that have macroscale structural integrity and properties that overlap with widespread materials
- Carbon powders that have potential use as additives in very large-scale systems, e.g., in soil or concrete

Examples of Value-Added Carbon Solids – Carbon Nanotubes (CNTs)

Carbon Hub

Opportunities

- ❑ CNTs can be synthesized in one process step from methane or light hydrocarbons
- ❑ CNTs can be converted into macroscopic materials;
- ❑ based on properties, a subclass of CNT macro-materials could replace metals or other construction material

Challenges

- ❑ CNT synthesis is still an early-stage, **low-volume** endeavor;
- ❑ synthesis **efficiency is low** and must be increased by orders of magnitude to attain competitiveness with incumbent materials;
- ❑ the **knowledge base** for increasing the efficiency and scale of CNT synthesis must be developed

VACS

Application in end-products

scale value

Examples of Value-Added Carbon Solids – Soil Amendment

Carbon Hub

Opportunities

- forms of carbon (e.g., biochar) may improve the fertility and viability of soils while simultaneously reducing fertilizer usage and the agricultural carbon footprint.

Challenges

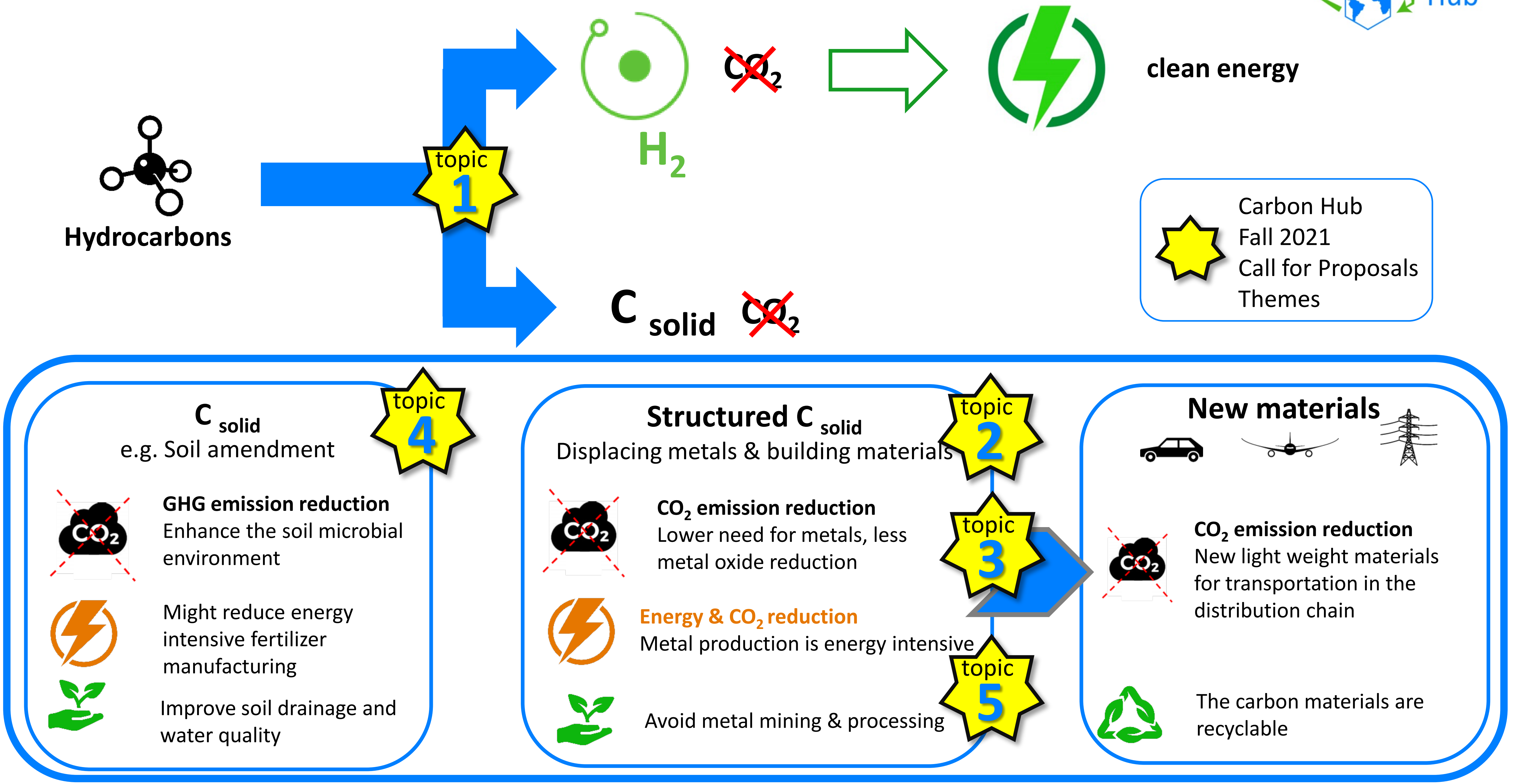
- current carbon soil additives are **too expensive** for large-scale deployment
- and are **not made from methane** and light hydrocarbons;
- the **knowledge base** for efficiently synthesizing soil additives from methane and light hydrocarbons must be developed

VACS

Application in end-products

scale value

The Carbon Hub aims to alter the Energy – Materials Nexus



Carbon Hub Webinar - Agenda

Carbon Hub

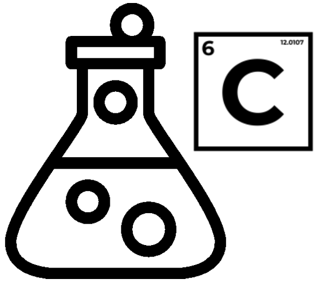
General	❑ Introduction Carbon Hub ❑ Mission and Vision	10 min
What are we trying to solve?	❑ Topic Introduction ❑ Expert deeper dive ❑ Key deliverables ❑ What is out of scope – What are we NOT looking for ❑ Budget and timeline	30 min
Q&A	❑ Please ask us questions	15 min
Next Steps	❑ In summary – How to submit your proposal ❑ Call for Proposal Process and timeline - Some Terms & Conditions	5 min

Overview Fall 2021 - Call for Proposal Topics

Carbon Hub

1

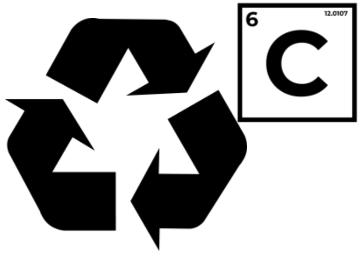
Improve understanding of the catalysis and reaction mechanism in (thermocatalytic) pyrolysis to efficiently convert methane to VACS.



2

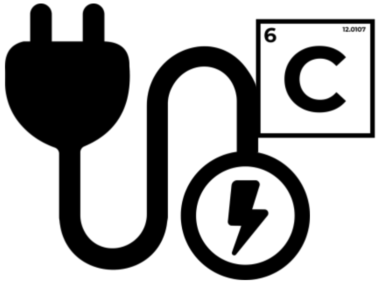
Improve Carbon nanotube [CNT] and VACS standardization and environmental impact understanding.

- CNT material standardization (terminology, testing)
- LCA and End-of-Life use mapped for CNT or other VACS



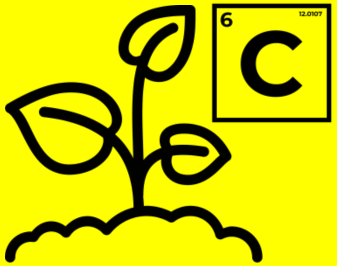
3

Demonstrate the value of a Carbon nanotube [CNT] fiber-based power cable prototype.



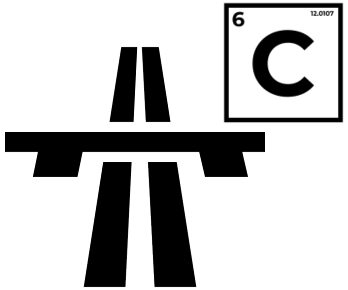
4

Demonstrate and explain efficacy of a VACS as a soil amendment.



5

Demonstrate the value of CNT or other VACS, in structural applications, including non-critical ones.

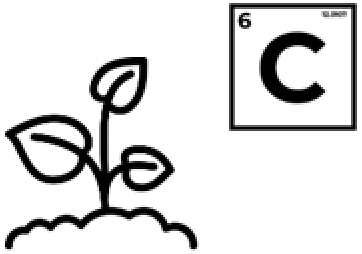


Carbon Hub

20th September 2021 Agenda:

- *Estimating Ecosystem Services from CH4-Derived Solid Carbon*

Demonstrate and explain efficacy of a VACS as a soil amendment.



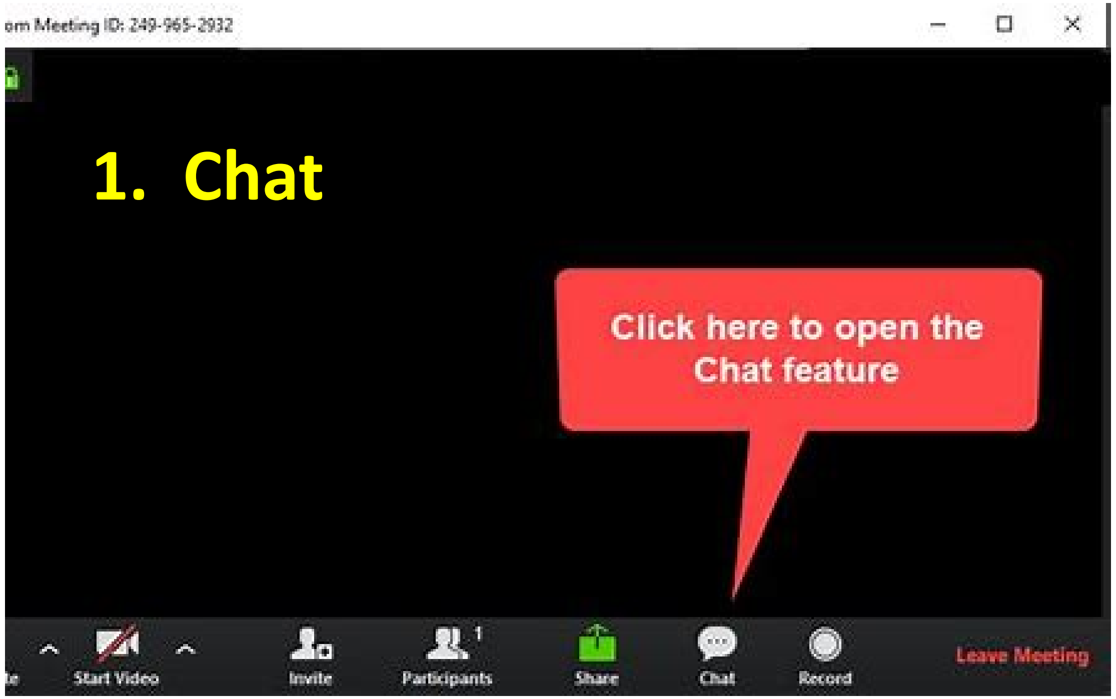
Dr. Carrie Masiello
Maurice Ewing Professor of Biogeochemistry

Daniel Cohan
Baker Institute Rice Faculty Scholar | Associate Professor of and Environmental Engineering

Carbon Hub 2020 CFP Cycle Awardee in Topic #4

RICE
Unconventional Wisdom

Q&A – Please ask us any questions you might have



The ideal soil amendment:

Carbon Hub

- Improves crop yields
- Improves ecosystem resilience to disturbances
  - Drought, floods, heat
- Provides environmental benefits
  - More carbon storage
  - Reduction in non-CO_2 greenhouse gas emissions
  - Reduction in soil gas emissions that cause urban air quality problems (NO_x species)

Biochar as a model for VACS
Biochar = charcoal made from plants for soil amendment.

These are all <u>emergent properties</u>: outcomes of changes in fundamental characteristics of the soil.

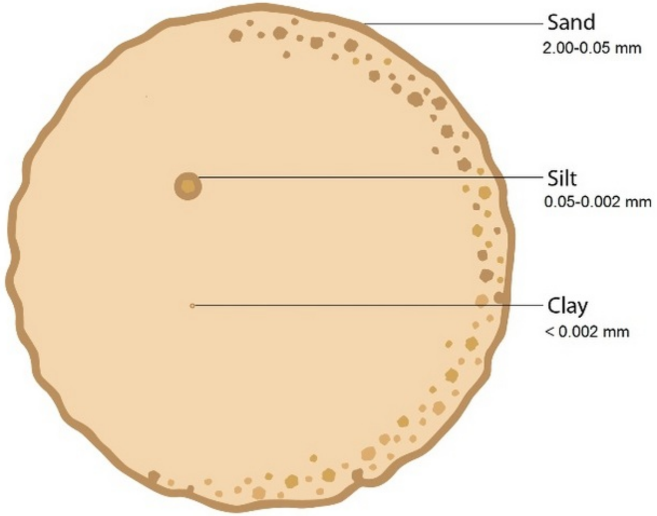
Next: engineerable characteristics.

Engineerable soil properties that deliver ecosystem services

Carbon Hub

- texture and structure
- Cation and anion exchange capacity
- Interaction with soil microbes driving ecosystem N and C fluxes

Texture is grain size. ~10^5 range.



Structure is aggregate size and is controlled by chemistry and biology.

Grains in this soil are ~10 nm

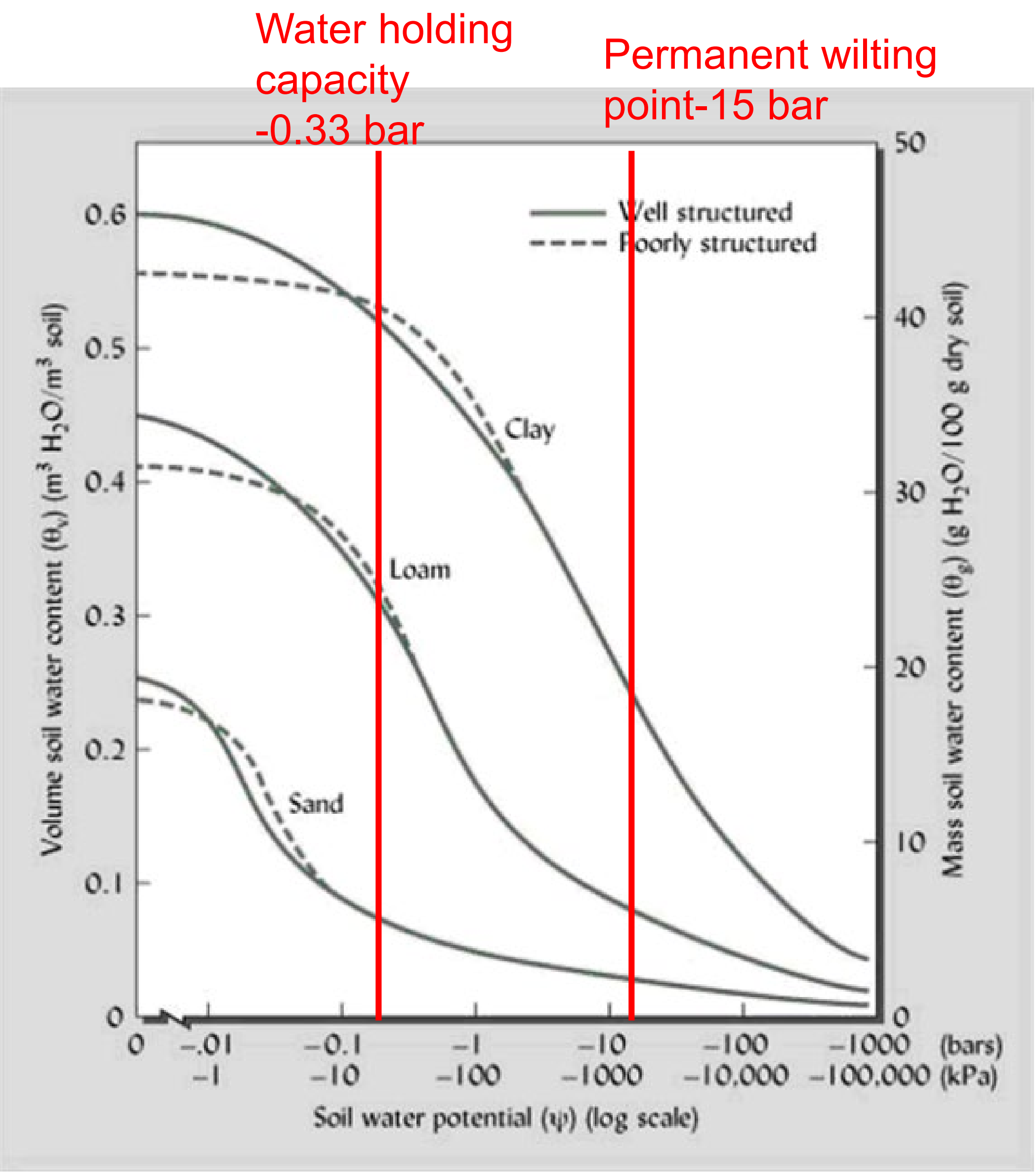
Texture is grain size. Structure is aggregate size.

First-order ecosystem service: multiscale porosity.

Houston soils (near Rice): grains are 10s of nm-scale. Aggregates are cm scale. Result: pores range from micron to mm scale.

Many pore sizes means water is held at many energies.

Between the two red lines is the sweet spot for fertile soil.



Brady and Weil, Nature and Properties of Soil, 2007.

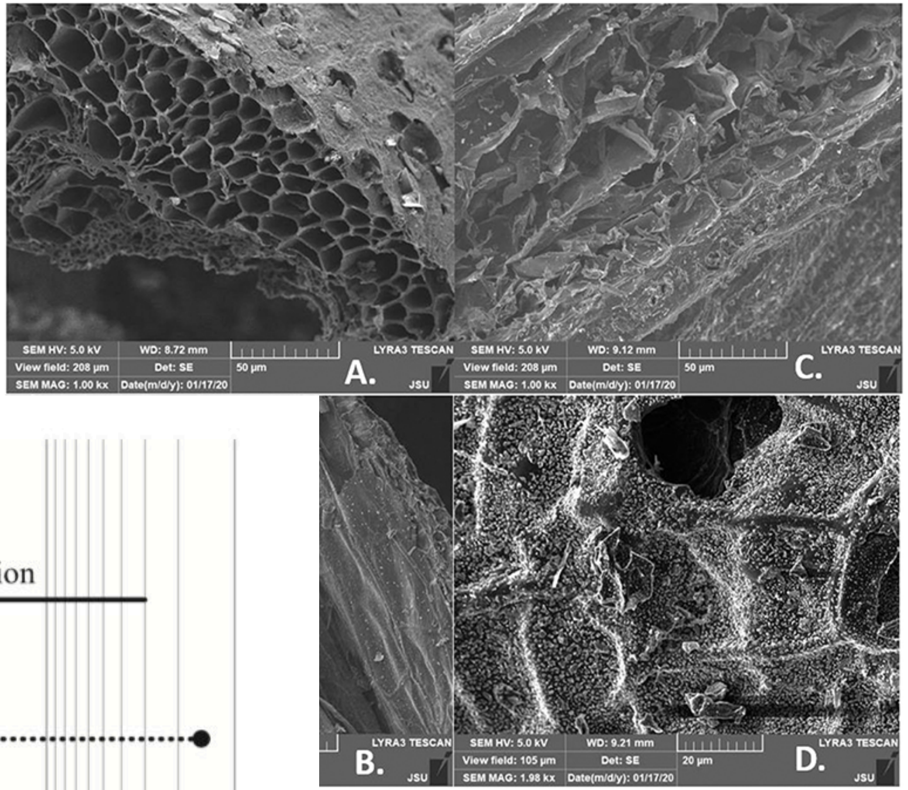
Soils can't retain water held above -0.33 bar.

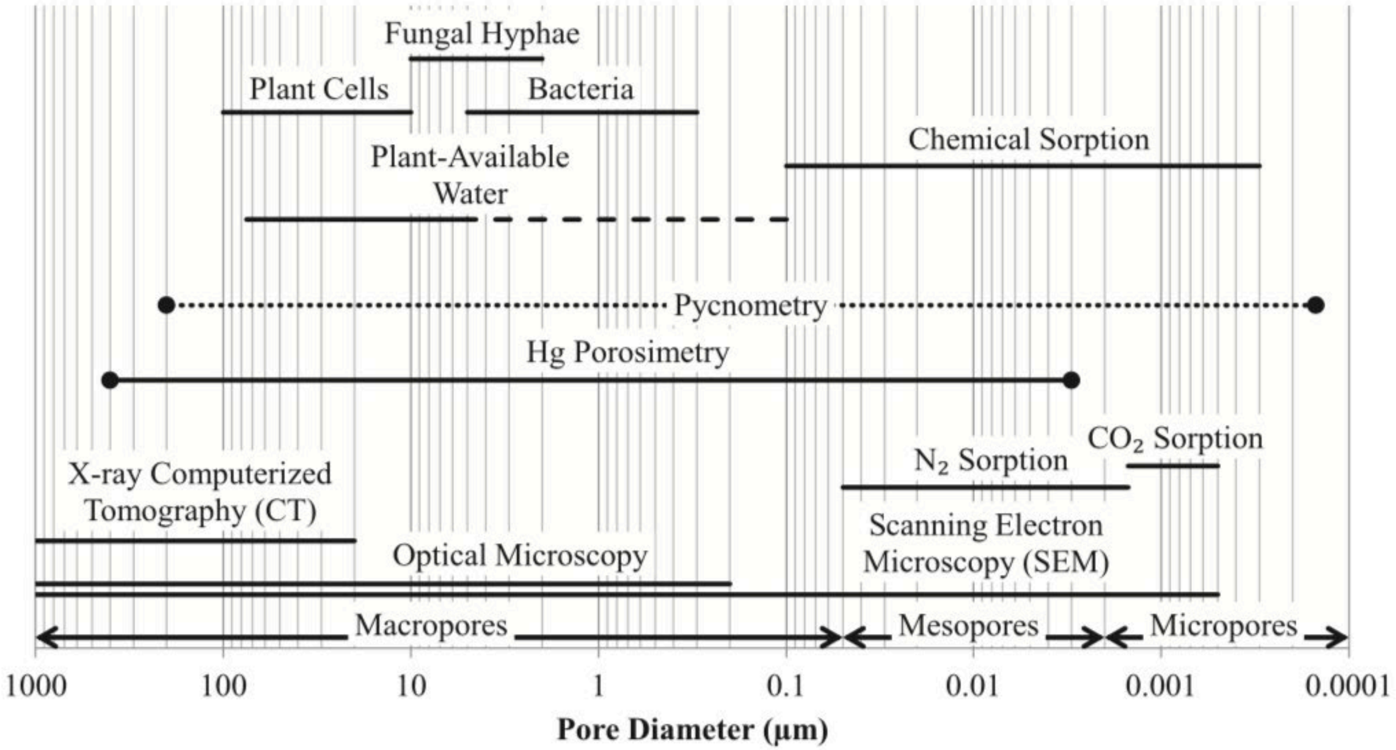
Plants can't access water held below -15 bar.

Multiscale porosity delivers water resilience to ecosystems.

Carbon Hub

- Some biochars do this.
- (aside: think about how you are measuring pores. Scale matters.)





Brewer et al. (2014). *Biomass and Bioenergy*, *66*, 176–185. http://doi.org/10.1016/j.biombioe.2014.03.059

Surface charges deliver nutrient storage capacity

Carbon Hub

- Plant nutrients: NO_3^-, NH_4^+, PO_4^{2-}, Ca^{2+} …

- ~90% of soil cation and anion exchange capacity comes from organic matter (e.g. carboxyl and carbonyl functionalities)

- Chromatographic column metaphor works well here.

- Biochar analog: 1000x more CEC than unamended soils
  - *But it all comes from the patina, not the aromatic groups.*

How to build a functional patina on VACS?

Carbon Hub

- Standard methods for creating weathering patina:
  - Needed for ecosystem services
  - Also needed to understand long-term fate (see Tuesday's webinar about standardization).

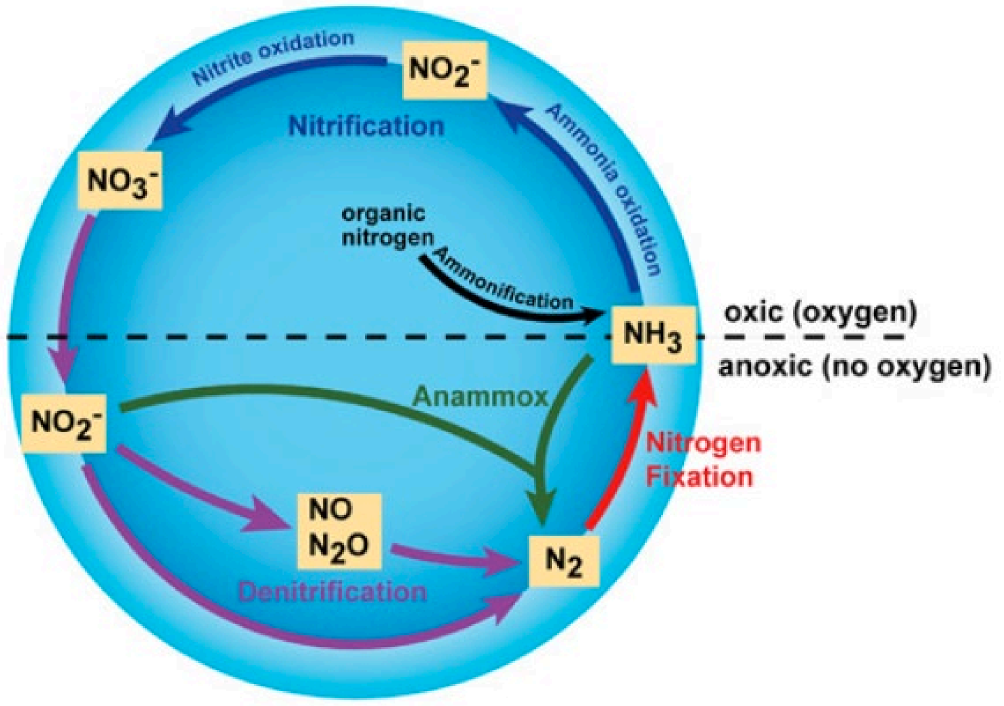
- Large body of analogous biochar literature on weathering surfaces

- Parallel literature on derivatization of carbonaceous nanomaterials.

Interactions with soil microbes

- Most complex; least understood

- In the case of biochar can sometimes deliver $ valuable ecosystem services
  - Alteration of the soil N cycle
  - Alteration of the soil C cycle

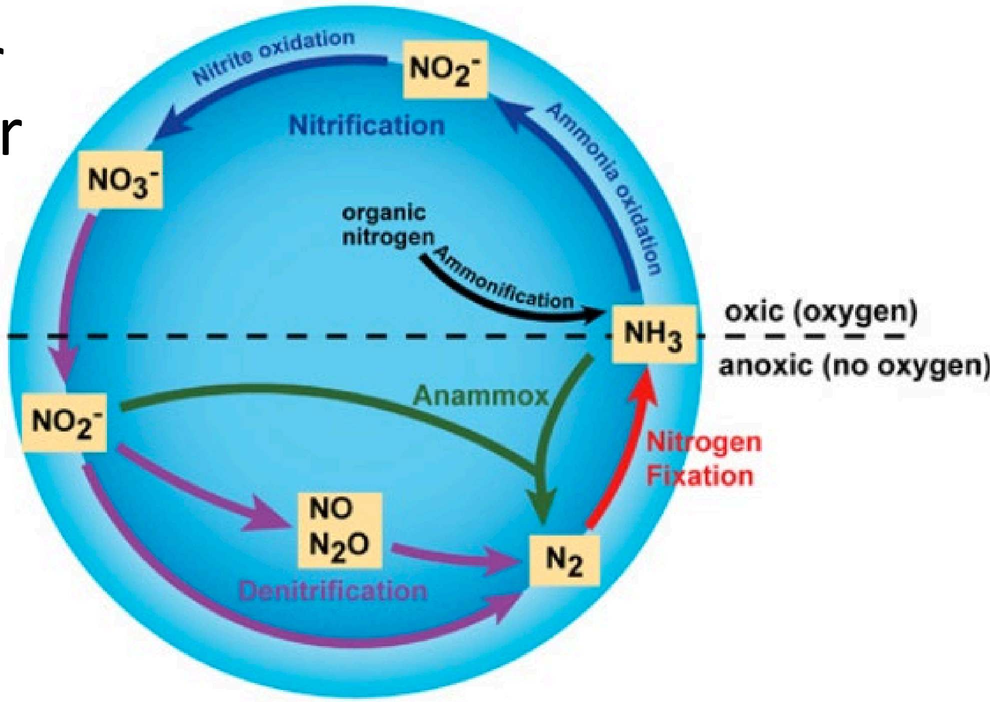


https://www.nature.com/scitable/knowledge/library/the-nitrogen-cycle-processes-players-and-human-15644632/

N cycle in soils:

Carbon Hub

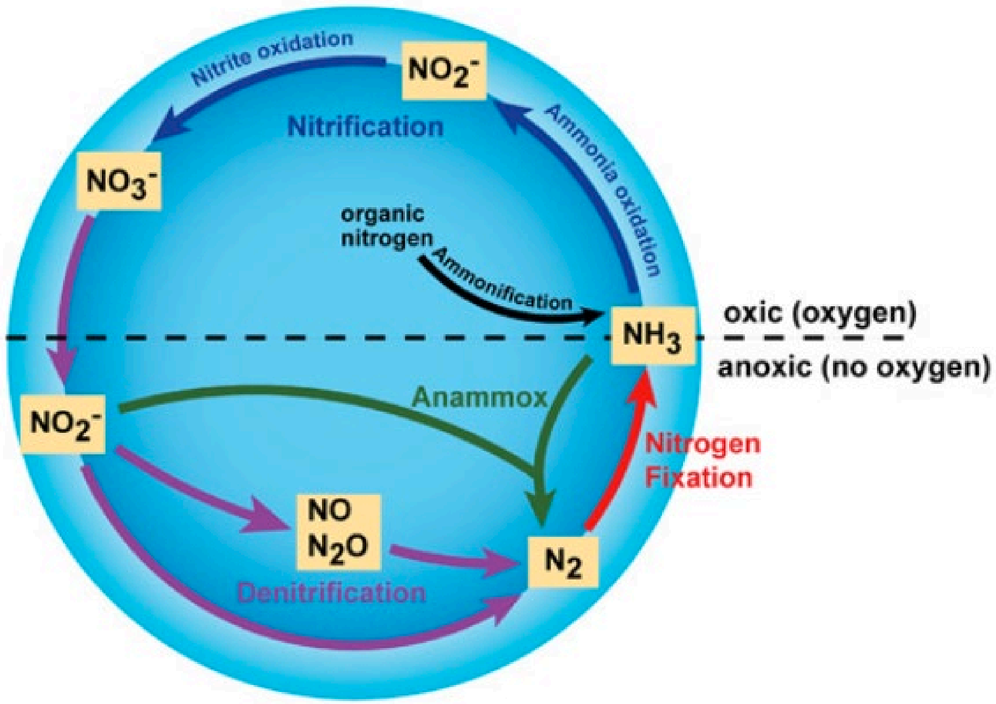
- Many possible oxidation states (NH_4^+ to NO_3^-)
- Microbes juggle N among > 7 oxidation states to extract energy and build biomolecules
- They quit wherever they run out of reactants or when energetics aren't favorable, dumping their waste products:
- NO, NO_2 = NO_x ; smog precursors
- N_2O = greenhouse gas and strat ozone depleter.



Sometimes biochar makes soil N cycling more efficient.

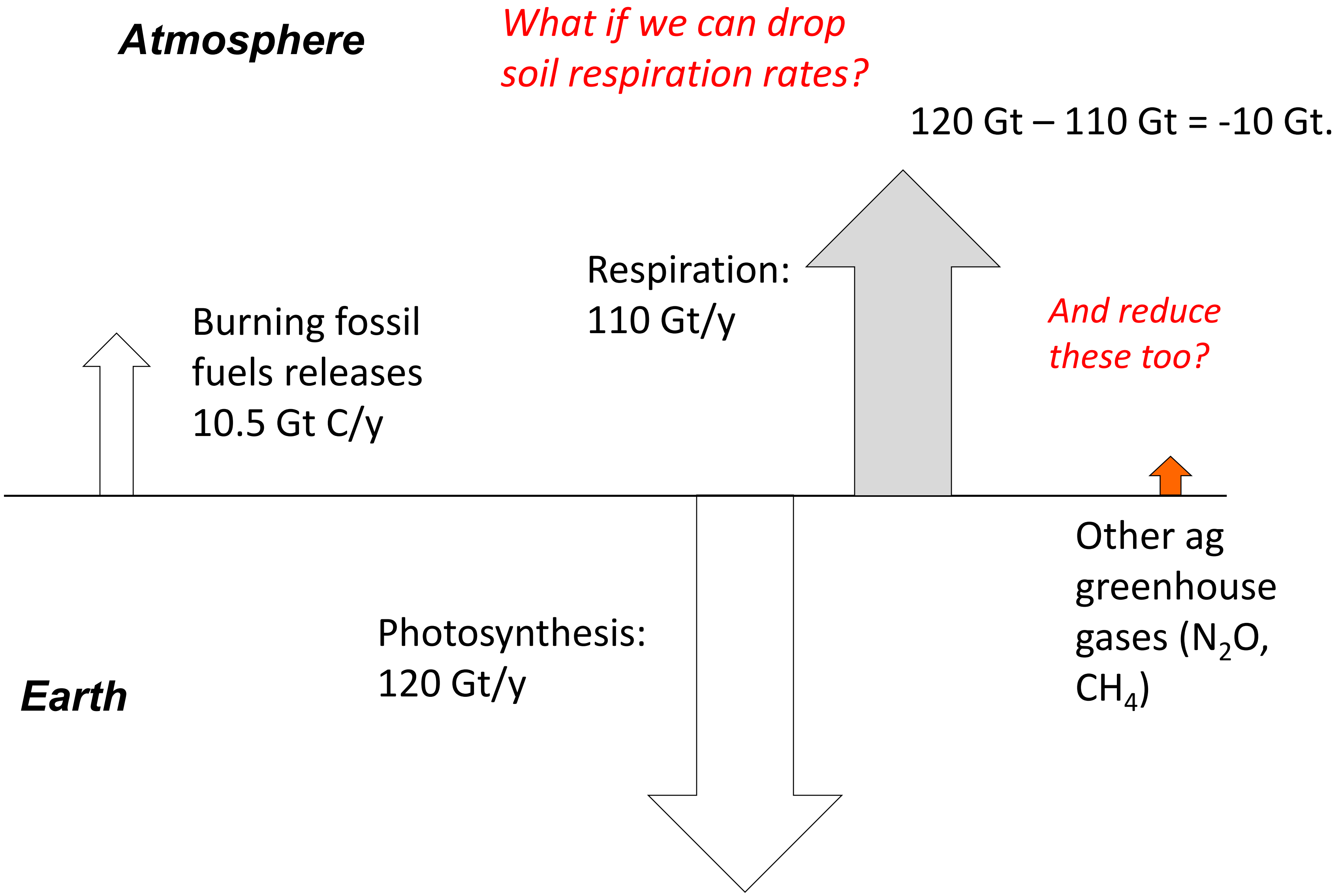
Carbon Hub

- Reduces NO_x and N_2O emissions
- Supplying e^- needed for reactions?
- Patina-derived Fe, Cu facilitating enzyme production?
- Creating multiscale porosity so both anoxic and oxic reactions can go forward?



Making a carbon sink

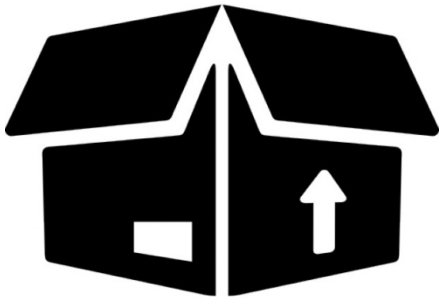
- Sometimes biochar alters soil microbial metabolism.
- Aromaticity supplies e- needed for metabolism?
- Porosity alters ecosystem structure?



Key research questions

- ❑ Following on Thursday’s talk: development of a standard weathering technique to estimate VACS properties 10-100 years after amendment
- ❑ How to post-process VACS into low-density, high porosity (nm to mm scale) particles that deliver desired water cycle ecosystem services and are easy to package and transport
- ❑ Determining, and then optimizing, VACS properties that alter soil nitrogen cycling
- ❑ Determining, and then optimizing, VACS properties that alter soil carbon cycling
- ❑ Estimating the cost benefits that land owners could accrue from VACS soil amendment

What deliverables are we looking for



Areas of Interest Include:

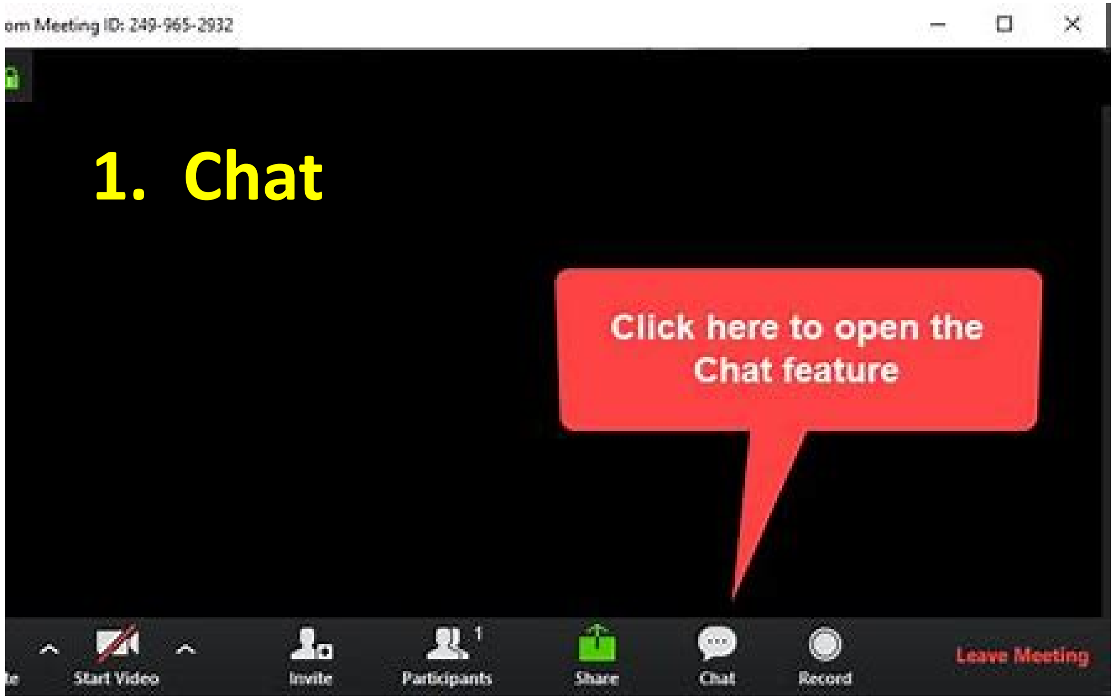
- ❑ How would VACS soil amendments affect:
  - ❑ Crop yield and quality
  - ❑ Carbon uptake by soils
  - ❑ N2O emissions
  - ❑ NO, NH3, NONO emissions
  - ❑ Run-off and leaching
  - ❑ Fertilizer application needs
  - ❑ Repetitive addition needs
- ❑ How does VACS performance compare with a selected biochar?
- ❑ Understand the VACS net carbon balance, nitrogen cycle and resultant greenhouse gas emissions
- ❑ Are VACS best used as powders or other macrostructures (foams, fibers, structures)

Carbon Hub Webinar - Agenda

Carbon Hub

General	❑ Introduction Carbon Hub ❑ Mission and Vision	10 min
What are we trying to solve?	❑ Topic Introduction ❑ Expert deeper dive ❑ Key deliverables ❑ What is out of scope – What are we NOT looking for ❑ Budget and timeline	30 min
Q&A	❑ Please ask us questions	15 min
Next Steps	❑ In summary – How to submit your proposal ❑ Call for Proposal Process and timeline - Some Terms & Conditions	5 min

Q&A – Please ask us any questions you might have



1. Chat

2. Raise your hand and we will invite you to speak

Carbon Hub Webinar - Agenda

Carbon Hub

General	❑ Introduction Carbon Hub ❑ Mission and Vision	10 min
What are we trying to solve?	❑ Topic Introduction ❑ Expert deeper dive ❑ Key deliverables ❑ What is out of scope – What are we NOT looking for ❑ Budget and timeline	30 min
Q&A	❑ Please ask us questions	15 min
Next Steps	❑ In summary – How to submit your proposal ❑ Call for Proposal Process and timeline - Some Terms & Conditions	5 min

Next Steps – How to submit

Carbon Hub

carbonhub.rice.edu/CFPCollaborators

RICE UNIVERSITY
Carbon Hub
Accelerating the Energy Transition Through Green Hydrocarbons

Menu

Carbon Hub - Call For Proposals 2021

On this page, you will find the Call for Proposals details that are restricted to our Collaborators only.

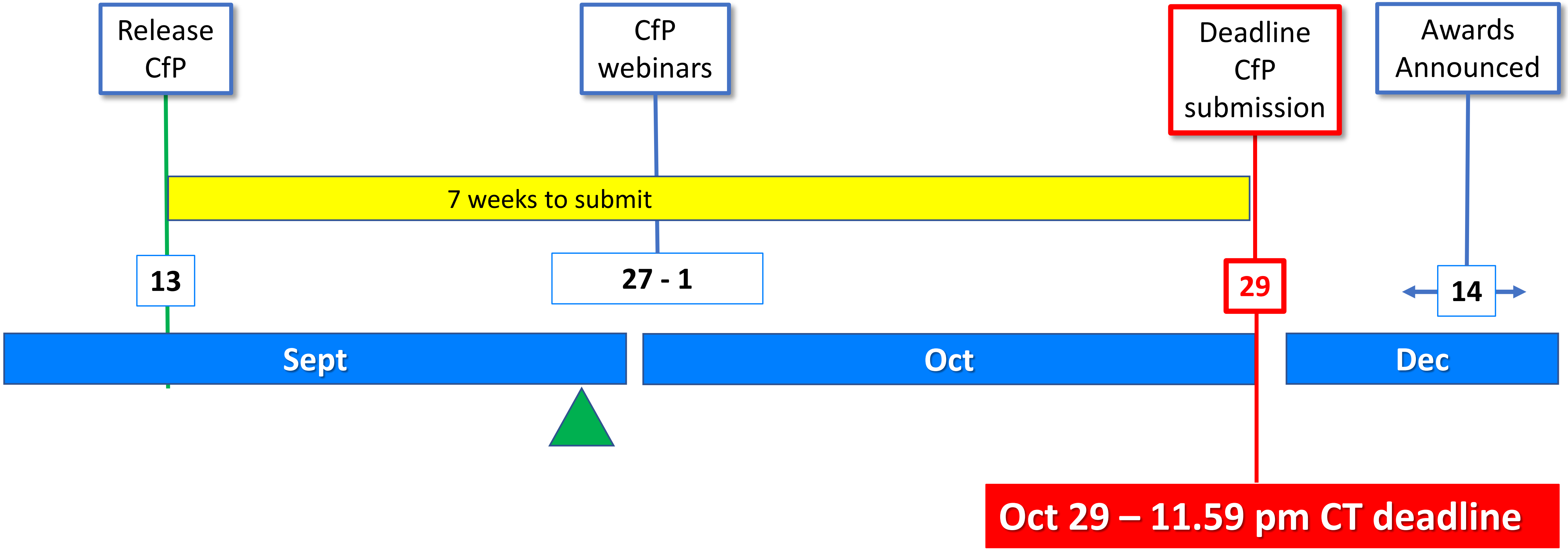
You may download the full Call for Proposals guidelines and instructions document in PDF form here.

**UPDATE: The Budget guidelines are attached here and the referenced spreadsheet can also be found here.

Please note, all Rice Collaborators should contact us directly at carbonhub@rice.edu to obtain the internal Budget template. That template cannot be shared with external Collaborators.

Oct 29 – 11.59 pm CT deadline

Call for Proposal Timeline



A Summary of the aspects we'd like you to address in your proposal (1/2)

Carbon Hub

CURRENT PROPOSAL SECTION	SECTION CONTENTS	PAGE LIMITATIONS
Executive Summary	Research Team a) Name of Principal Investigator(s) b) Affiliation – institute c) Address, city, country Contact details: email and phone Topic # and Proposal Title Abstract	1
Innovation, Impact, and Linkage to Carbon Hub Vision	How are you addressing the Topic Challenge? Provide a concise description of why the proposed research will further the Carbon Hub Vision.	1
Proposed Work	What techniques & knowledge will you use? Provide a concise description of the equipment, technology and knowledge you will be using. Why is this an effective way to address the challenge? Provide a concise description why your approach is an effective and innovative way to create new insights and value. What are the key deliverables?	4

A Summary of the aspects we'd like you to address in your proposal (2/2)

CURRENT PROPOSAL SECTION	SECTION CONTENTS	PAGE LIMITATIONS
Team Organization and Capabilities	What is the team to address this challenge? Concise description of research team actively working on proposed effort: names, project roles. Why should we fund your team? What is the team's expertise and capabilities? Concise description of key expertise and capabilities as related to the project approach.	1
Budget	Breakdown by categories, including any cost share. (budget template will be provided by September 30, 2020)	1
References cited	Includes both literature references and references to earlier work by the proposing team.	2
Personnel Qualifications Summaries	NSF-style preferred	2 pages per person
Risks and Other Insights	What are the key risks in your approach? How are you managing the risks? What else might be important?	1

Some of the Terms & Conditions

- ❑ **The primary Principal Investigator (PI) must be a Carbon Hub Academic Collaborator** (https://carbonhub.rice.edu/collaborators) to be eligible to submit a proposal
- ❑ If you are not currently a Collaborator, please inquire at **carbonhub@rice.edu**

- ❑ **Fall 2021 : $1.5+ million budgeted for new and continuing awards**
- ❑ Anticipate~~s~~ granting 4 - 7 awards across the 5 Topic areas
- ❑ **Individual awards may vary between $50,000 and $250,000**
- ❑ For PIs who are not at Rice University, funding will start upon successful negotiation of a subcontract between Rice University and their home institution
- ❑ Funding agreements are expected to launch in Feb 2022, or once negotiations are complete

Results can be published – THEY ARE <u>NOT</u> CONFIDENTIAL
Results will be shared with Carbon Hub members

Further details on the Carbon Hub website and in the Call for Proposal documents

Carbon Hub Webinar - Call for Proposals Fall 2021

Carbon Hub