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Re: Response to Request for Information (RFI) Opportunities for Additional Support for Commercial Direct Air Capture (DAC) Demonstration Facilities (DE-FOA-0003478)

Dear Acting Director Cummins,

Thank you for the opportunity to respond to your October 29, 2024 RFI regarding opportunities for additional support for Commercial Direct Air Capture (DAC) facilities. The Direct Air Capture Coalition (DAC Coalition) is a global non-profit organization consisting of over 110 companies, civil society groups, and research and academic institutions located around the world working together to advance and accelerate the responsible development and deployment of direct air capture technology to help address climate change. We are responding in partnership with the Carbon Business Council, a nonprofit trade association of more than 100 innovative carbon management companies with over $16.5 billion in combined assets working across six continents.

Below are responses by categories noted in the RFI.

Request for Information Categories and Questions

Category 1: Questions related to supporting individual DAC projects (Note: all questions are optional)

1. Does the Description section above accurately characterize the situation facing DAC developers, credit buyers, and investors, and reflect the potential options and tradeoffs related to a demand-side or non-capex support program? If not, why not?

The Direct Air Capture Coalition (DACC) and Carbon Business Council appreciate the Department of Energy's (DOE) focus on addressing the challenges faced by DAC developers, credit buyers, and investors. We generally agree that the description accurately reflects the current landscape and the importance of non-CAPEX support mechanisms. However, there are

critical areas that require additional emphasis and refinement to ensure equitable and effective support for the nascent DAC industry.

1. **CAPEX and Non-CAPEX Support**
   The Description appropriately highlights the vital role of government support—including CAPEX, OPEX, and demand-side mechanisms—in supporting DAC projects at this stage of the industry's development. This level of support is expected and necessary for an early-stage energy and infrastructure sector. We agree that DOE should explore optimization strategies for deploying these supports based on the unique needs of individual projects rather than treating them as interchangeable.

2. **Role of CAPEX Support**
   While the Description focuses on non-CAPEX funding, we would like to reiterate that CAPEX support is urgently needed to:
   - Attract the equity financing required for first-of-a-kind (FOAK) projects.
   - Reduce technology risk and high balance-of-plant (BOP) costs, which currently deter debt or project financing. Without robust CAPEX support, many DAC developers—especially those with smaller balance sheets—will struggle to finance and deploy their projects, creating disparities in the industry's growth, potentially causing technology lock-in which could adversely impact longer term cost trajectories.
3. **Importance of OPEX Funding**
   OPEX funding is essential for new and existing projects to achieve profitability and scalability. DAC technologies are in the early stages of development, and their operational costs—driven primarily by sorbent and energy expenses—remain high. Targeted OPEX support can:
   - Make projects more attractive to investors and reduce credit prices, increasing accessibility for buyers.
   - Drive steady demand for sorbent and material suppliers, stimulating competition and innovation.
   - Lower the cost curve for DAC technologies over time.
4. **Market Dynamics and Demand Creation**
   The current DAC market faces a significant gap in funding due to a limited pool of committed carbon removal credit buyers. Programs such as direct DOE purchases of DAC credits or mechanisms that derisk investments (e.g., long-term contracts) would:
   - Build confidence among private investors and buyers.
   - Unlock critical investments in DAC infrastructure and technologies.
   - Accelerate overall decarbonization efforts by creating a stable, predictable demand signal.
5. **Support for Modular and Distributed DAC**
   Modular, distributed DAC systems, which often operate at smaller scales, face distinct challenges due to high OPEX. Tailored support for these projects can drive innovation, enable deployment in diverse geographies, and lower per-ton CO_2 removal costs.

While the description effectively captures many of the challenges facing the DAC industry, it must also emphasize:

- The urgent need for CAPEX and OPEX funding to reduce costs and enable FOAK projects.
- Strategic demand-side mechanisms that are phased in alongside foundational CAPEX and OPEX support to ensure industry growth.
- Enhancements to MRV systems to bolster market credibility and uptake.

We'd like to also emphasize the considerable heterogeneity within the DAC sector. There are over 50 direct air capture technology companies that are members of the Direct Air Capture Coalition and many of these companies are at different stages of their scaling journeys. Differences in their financial positions, balance sheets, scaling trajectories, and TRL levels, among others, may lead to a variety of perspectives on how public support can be maximally catalytic. These comments are meant to provide the greatest degree of consensus possible regarding common challenges and opportunities for support.

The DAC Coalition and Carbon Business Council appreciate DOE's efforts to address these critical issues and look forward to continued collaboration to ensure the DAC industry's success in driving climate solutions.

2. To what extent is financing for DAC projects contingent on, and currently held back by the lack of demand for DAC carbon removal credits, and what are the reasons?

Financing for large-scale DAC projects heavily depends on demand for DAC carbon removal credits, as investors require clear revenue streams to justify investments. The lack of sufficient demand and offtake agreements limits financing, particularly in an early-stage market with unproven economics. For mid-scale projects, first-of-a-kind (FOAK) financing risks make it difficult to secure project financing, even if demand were fully allocated.

Barriers to Demand and Investment:

- **High Credit Costs:** DAC credits are intrinsically more durable, scalable, and measurable as well as significantly more expensive than credits from other CDR pathways such as less durable nature-based alternatives, discouraging buyers focused on cost.
- **Regulatory Gaps:** The absence of mandatory compliance markets or strong regulatory frameworks limits demand.
- **Voluntary Market Complexit**y: Actors on the voluntary carbon market often lack guidance pertaining to DAC, or CDR more generally, as it relates to corporate sustainability reporting.
- **Paucity of Commercial DAC projects:** Without more functioning commercial DAC projects, investors are unable to discern whether DAC developers can deliver projects.
- **Investor Hesitation:** Uncertainty around long-term policy regimes and market stability increases financial risk, compounded by high capital costs for FOAK projects.

Role of Government Support: Programs like 45Q help offset costs but are insufficient alone. Expanding incentives, assuring policy continuity, and creating demand through direct government credit purchases or long-term contracts can derisk investments and attract private capital.

A comprehensive approach—combining CAPEX funding, operational subsidies, and robust demand signals—is essential to scale the DAC market and unlock financing. DOE's leadership in fostering demand and policy stability is critical to overcoming these challenges.

3. To what extent do 45Q tax credits enable the continued operation of DAC projects post-construction? What are the pros and cons of subsidization via 45Q tax credits for prospective DAC projects?

The 45Q tax credit is vital for sustaining DAC projects post-construction by providing up to $180 per ton of CO_2 geologically stored, offsetting significant operational costs. However, its limitations require complementary measures to maximize impact.

Key Benefits of 45Q:

- **Operational Support:** Offsets high OPEX, especially for early-stage projects.
- **Investor Confidence:** Establishes reliable revenue streams, reducing financial risks.
- **Policy Stability:** 45Q is law and its bipartisan backing provide greater long-term reliability.
- **Workforce Development:** Encourages prevailing wage and apprenticeship standards.
- **Stackability**: 45Q can be additional to other tax incentives and voluntary carbon market credit sales

Limitations of 45Q:

- **Insufficient Coverage:** High energy and sorbent costs often exceed credit value, especially for non-geological storage.
- **Limited Eligibility Period:** Projects are only eligible for 45Q for 12 years when most large-scale DAC projects will operate for 20+.
- **Delayed Benefits:** Annual tax filings delay financial returns; upfront subsidies could address this.
- **Inflationary Erosion:** Static credit value diminishes real-world impact over time.
- **Limited Scope:** Excludes pre-sold credits in voluntary markets, crucial for early investment.
- **Overly Narrow Eligibility for Durable Sequestration:** Certain means of permanent and durable CO2 storage, such as mineralization, are not eligible for the full $180/ton credit, despite providing long term, measurable storage.

Broader Impacts:

- Drives decarbonization in hard-to-abate sectors.

- Attracts investment in innovative DAC technologies.
- Promotes equitable project development across diverse regions.

While indispensable, 45Q requires enhancements and additional support mechanisms to fully realize DAC's potential. Inflation adjustments, extended eligibility, and complementary subsidies will ensure its long-term effectiveness in scaling DAC technologies and advancing climate goals. DOE cannot directly address all these limitations (which require Congressional action), but it can provide complementary OPEX and demand-side mechanisms that address underlying issues.

4. What other obstacles may hinder investment in DAC projects?

Investment in DAC projects faces several key obstacles:

1. **High Costs**: Significant upfront capital and high operational expenses deter investors, especially for FOAK facilities.
2. **Energy Challenges**: DAC's reliance on large-scale renewable energy creates hurdles in regions with constrained capacity.
3. **Lack of Policy Support**: Absence of mandates or incentives for private-sector participation and insufficient regulatory frameworks hinder growth.
4. **Few Operating Commercial Projects:** Lack of working DAC projects increases perceived risk in the industry.
5. **Storage and Permitting Delays**: Limited access to Class VI wells and public concerns about sequestration impact project feasibility.
6. **Small-Scale Barriers**: Insufficient funding and limited investor universe for smaller projects delays innovation and modular deployment.
7. **Uncertain Demand**: Voluntary markets alone can't justify large-scale investments, and the high cost of DAC credits limits buyer interest.
8. **Cost Competitiveness**: While DAC credits are currently more expensive than alternatives like nature-based solutions, it is critical to emphasize that DAC credits offer superior durability and measurability. These attributes make them fundamentally different and higher quality, meaning they should not be directly compared on price alone. The market must evaluate credits on a "like-for-like" basis, where attributes such as permanence and verifiability are appropriately valued.
9. **MRV Standards**: Lack of clear protocols undermines market confidence.

Recommendations: Address these challenges with comprehensive policy support, enhanced financial incentives, expanded renewable infrastructure, streamlined permitting, and innovations in modular deployment. Tackling these barriers will improve cost-competitiveness and accelerate DAC scalability.

5. When comparing DAC facilities at small-scale (500–2,000 tons per annum, TPA), mid-scale (2,000–25,000 TPA) and large-scale (25,000+ TPA), are there unique aspects to the relationship between raising investment capital and pre-committed demand? Are the investor or credit buyer requirements different across those scales (beyond what an increase in size would imply for total volumes and amounts)?

When comparing DAC facilities at small-scale (500–2,000 tons per annum, TPA), mid-scale (2,000–25,000 TPA), and large-scale (25,000+ TPA), there are significant differences in the relationship between raising investment capital and pre-committed demand. These differences

reflect the varying risk profiles, investor expectations, and credit buyer requirements across scales.

1. Small-Scale DAC Facilities (500–2,000 TPA)

- **Nature of Projects**: Small-scale projects are typically early-stage, experimental, and focused on technology validation rather than commercial profitability. These facilities often act as testbeds for innovation and data collection, with limited capacity to generate marketable carbon credits due to their size and higher per-ton costs.These projects often lack the ability to fund the necessary infrastructure for their project, such as compressors, purifiers, or storage sites which have high CAPEX hurdles. Enabling small and perhaps medium sized DAC companies to pool resources for these technical aspects of their projects would be impactful.
- **Investor Characteristics**:
    - Investors at this scale are willing to accept high risks in exchange for the potential of achieving high returns as well as supporting high-impact climate technologies.
    - There is little expectation of immediate profitability, and any credit sales are considered supplementary rather than essential to the investment decision.
- **Credit Buyer Requirements**:
    - Buyers prioritize transparency, robust MRV (Monitoring, Reporting, and Verification), and proof of carbon removal. They are generally more flexible on cost per ton.

2. Mid-Scale DAC Facilities (2,000–25,000 TPA)

- **Nature of Projects**: Mid-scale facilities represent the transition between pilot projects and commercial-scale deployment. These projects start benefiting from some economies of scale but remain costly due to technology maturity and high operational expenses.
- **Investor Characteristics**:
    - Investors include private equity firms, venture capital, and green investment funds seeking a balance between technology validation and financial returns.
    - Pre-committed demand, typically in the form of offtake agreements with corporate buyers, is essential to de-risk investments. These agreements often cover operational costs (OPEX) rather than capital costs (CAPEX).
- **Credit Buyer Requirements**:
    - Buyers expect lower per-ton costs compared to small-scale projects, as mid-scale facilities leverage improved operational efficiencies. They require assurances of credit quality, durability, and compliance with emerging standards with increasing scrutiny on MRV.

3. Large-Scale DAC Facilities (25,000+ TPA)

- **Nature of Projects**: Large-scale projects aim for full commercialization and significant cost reductions through economies of scale. However, very few DAC developers currently have the capacity to pursue projects at this scale.
- **Investor Characteristics**:
    - These projects attract institutional investors, infrastructure funds, and government financing. Financing structures often involve a mix of equity and structured debt.
    - Long-term offtake agreements or government-backed support, such as 45Q tax credits, are critical to secure the significant upfront capital required.

    - Investors prioritize mature technologies with robust risk mitigation strategies and stable revenue streams.
- **Credit Buyer Requirements**:
    - Buyers at this scale are typically corporations with net-zero commitments or governments procuring credits for compliance markets. They require competitive pricing and strict adherence to MRV, additionality, and durability standards.
    - Guarantees of permanence, such as insurance or escrow mechanisms, are often necessary to address risks of credit reversals as well as failure of credit delivery.

4. Key Challenges Across Scales

- **Chicken-and-Egg Problem**: DAC developers face a "valley of death" where significant capital is needed to scale up projects, but the high cost of credits and uncertain market conditions deter investment. This is particularly pronounced for projects transitioning from mid-scale to large-scale.
- **Importance of CAPEX and OPEX Support**:
    - Small- and mid-scale projects require CAPEX funding to overcome high upfront costs and demonstrate viability.
    - Large-scale projects also depend on OPEX support to maintain cost competitiveness while reducing technology risks through continued deployment.

Each scale of DAC facilities has unique investment dynamics and credit buyer requirements. While small-scale projects emphasize innovation and early-stage validation, mid- and large-scale projects require greater pre-committed demand and risk mitigation to attract institutional investors and corporate buyers. A tailored approach to CAPEX and OPEX support is essential to bridge these gaps and enable the DAC industry to scale effectively. DACC recommends DOE prioritize funding mechanisms that address the specific needs of projects at each stage of development.

6. What would lead to more voluntary purchases of DAC credits?

To boost voluntary purchases of DAC credits, key strategies include:

1. **Government Support:**
    - Federal credit purchases and subsidies can signal demand, stabilize prices, and lower costs for buyers.
2. **Develop Voluntary Buyer Matching Mechanism:**
    - Use matching purchases to build market momentum, designed primarily as a supplemental strategy, particularly for smaller-scale projects.
3. **De-Risk Purchases:**
    - Credit guarantees and insurance mechanisms reduce buyer concerns over project risks, encouraging broader participation.
4. **Transparency and Differentiation:**
    - Standardized MRV systems and educational campaigns highlight DAC's durability and quality compared to other carbon removal options.
5. **Market Awareness:**

    - Corporate net-zero commitments and public education campaigns drive demand by emphasizing DAC's role in addressing climate challenges.
6. **Aggregation and Marketplaces:**
    - Platforms for smaller buyers and pooled demand structures make credits accessible and reduce transaction costs.
7. **DAC Cost Reduction:**
    - Supporting more technology innovation and the deployment of more DAC technology platforms will bring down the cost of credits.
8. **Incentives:**
    - Expanded tax benefits and CSR-driven co-investment lower costs and attract private-sector buyers.
9. **Leadership and Public Relations:**
    - High-profile corporate commitments and endorsements build market confidence and normalize DAC credit purchases.
    - Engage in outreach to state and local governments to enhance awareness and acceptance of DAC.
10. **Address Barriers:**
    - Streamlined permitting and public trust in geological storage accelerate project deployment and credit availability.
    - Provide tools for states to apply for Class VI primary.
11. **Expand Supply:**
    - CAPEX funding for small-scale projects decreases buyer hesitancy by increasing supply and reducing perceived delivery risk.

Combining these approaches will stimulate demand, enhance market trust, and build a robust voluntary market for DAC credits. DOE and stakeholders should prioritize these efforts to unlock DAC's potential.

7. What terms and conditions should be standardized to facilitate a broader marketplace for DAC credits?

Standardizing terms and conditions for DAC credits is crucial for building trust, simplifying transactions, and fostering a robust marketplace. Key recommendations include:

1. **Credit Definitions**:
    - Define DAC credits based on durability and additionality. Differentiate them from other removal approaches, emphasizing durability and measurability.
2. **Standardized Contracts**:
    - Use uniform offtake agreements covering transferability, timelines, and liability to streamline transactions and reduce legal complexity.
3. **Transparency**:
    - Mandate public disclosure of credit origin, storage methods, and lifecycle

emissions. Utilize registries to track issuance and prevent misuse.

4. **Energy Standards**:
    - Allow flexibility for clean energy sources and value waste energy use to reduce strain on energy systems.
5. **Credit Retirement**:
    - Ensure credits are permanently retired upon use to maintain market integrity and prevent double counting.

By implementing these standards, DOE can simplify the DAC credit market, build trust, and attract broader participation. These measures will support both voluntary and compliance markets, enabling DAC to scale effectively and contribute to global climate goals.

8. Are uncertainties about credit eligibility in current or future compliance regimes or voluntary commitment frameworks holding back corporate credit purchases? What clarifications or changes would be required to address these uncertainties?

Yes, uncertainties about credit eligibility in compliance regimes and voluntary frameworks hinder corporate purchases of DAC credits. Buyers need clarity and consistency to make long-term investments.

Key Barriers:

1. **Voluntary Markets:** Lack of guidance from frameworks like SBTi on DAC's role in net-zero targets reduces corporate confidence. Lower-cost offsets often dominate, sidelining DAC credits.
2. **Compliance Markets:** Misaligned standards and unclear rules create discrepancies in eligibility, accounting, and pricing, deterring corporate participation.

Required Clarifications:

- **Define DAC's Role:** Establish clear guidelines for DAC credits' contribution to corporate climate goals, emphasizing permanence and measurability.
- **Standardize MRV:** Develop uniform Monitoring, Reporting, and Verification protocols to ensure transparency and credibility.
- **Harmonize Standards:** Align voluntary and compliance frameworks to reduce entry barriers and build market consistency.
- **Enhance Transparency:** Publicly disclose eligibility criteria, storage methods, and lifecycle emissions to boost buyer confidence.

Clarifying DAC's role, aligning standards, and improving transparency will enable corporate adoption, fostering a reliable market for DAC credits. DOE and stakeholders must prioritize these actions to unlock demand and support the DAC industry.

9. How would a DAC project developer prefer to allocate federal award funding to either: 1) offset construction costs, 2) offset operating costs, and/or, 3) a demand support mechanism or program, if given the choice to propose any allocation?

DAC developers prefer flexible federal funding tailored to project maturity and specific needs. Key funding priorities include:

1. **Construction Costs (CAPEX):**
   Essential for early-stage projects to offset high upfront costs, secure financing, and validate technologies. CAPEX funding establishes foundational infrastructure critical for first-of-a-kind (FOAK) facilities.

2. **Operating Costs (OPEX):**
   Vital for mid-scale and modular projects transitioning to commercial viability. OPEX funding covers high energy and material costs, ensuring ongoing operations and economies of scale.

3. **Demand Support Mechanisms:**
   Key for mature projects to stabilize revenue through credit subsidies, advanced market commitments, or government credit purchases. Long-term offtake agreements attract private investment and ensure market stability.

4. **Flexibility in Allocation:**
   At this early stage of DAC deployment, funding should be flexible to align with individual project scale and context. This could mean prioritizing CAPEX for early-stage projects, OPEX for scaling operations, and demand-side mechanisms for market-ready facilities.

Flexible funding ensures projects progress efficiently across stages, reducing risks, driving deployment, and fostering a robust DAC industry. DOE is encouraged to adopt funding structures addressing these varied needs to maximize federal investment impact.

10. How valuable would developers find the option described in the previous question, and why?

Developers highly value flexible federal funding that addresses construction, operating costs, and demand support, as it maximizes impact by adapting to project needs at different stages:

1. **Flexible Allocation:**
   Tailored funding helps mitigate upfront capital costs, cover operational expenses, and stimulate market demand, ensuring alignment with project maturity and scale.

2. **Construction Cost Support (CAPEX):**
   Essential for early-stage projects to validate technologies, attract private investment, and progress to commercial deployment. CAPEX funding fills gaps left by grants and prizes, ensuring project feasibility.

3. **Operating Cost Support (OPEX):**
   Critical for modular and mid-scale projects facing high operational expenses. OPEX funding enables these projects to scale, bridge profitability gaps, and achieve sustained operations.

4. **Demand Support Mechanisms:**
   Long-term purchase agreements or guaranteed credit prices stabilize revenue, reduce market risks, and attract private capital. Such mechanisms drive economies of scale, innovation, and cost reductions.

5. **Energy and Compliance Challenges:**
   Issues like clean energy matching and additionality can be addressed through commercialized deployment and integration with broader energy systems.

Flexible funding ensures DAC projects progress efficiently across stages, from early development to maturity. DOE is urged to adopt this approach to accelerate DAC deployment and maximize federal investment impact.

11. What potential forms of demand-side support or other non-capex support would be most valuable in stimulating DAC deployments, and why? What overall program characteristics (e.g., total program funding amount, program duration) would give these forms of support the most impact? For purposes of this question, when responding please assume that any funds for a new program would come from remaining funds available under the Regional DAC Hubs provision. Feel free to comment on any of the examples below or describe others not mentioned.

> *a. Federal government (or affiliate) direct purchase of credits (e.g., advanced market commitment)*
>
> *b. Subsidy of third-party credit purchase (e.g., 45Q top-up or extension, contract for difference, flat subsidy)*
>
> *c. Minimum throughput guarantees for key DAC hub infrastructure (e.g. transport and storage)*
>
> *d. Subsidy of ongoing operations and maintenance (O&M) costs to lower the facility's effective cost of capture*

The most valuable demand-side or non-CAPEX support for DAC deployments should focus on reducing costs, stabilizing revenue, and driving market demand. Key support forms include:

1. **Federal Credit Purchases (Option a):**

    - Acts as a strong demand signal to boost investor confidence and catalyze private-sector participation.
    - Supports DAC hubs in reaching Final Investment Decision (FID) and establishes a precedent for broader procurement programs.

2. **Subsidies for Third-Party Credit Purchases (Option b):**
    - Reduces credit costs for buyers, increasing affordability and encouraging corporate participation.
    - Attracts voluntary market buyers balancing environmental goals with budget constraints.
3. **Minimum Throughput Guarantees (Option c):**
    - Ensures availability of transport and storage infrastructure, reducing operational risks.
    - Addresses regional infrastructure bottlenecks, enabling scalability.
4. **O&M Subsidies (Option d):**
    - Lowers the cost of carbon capture, especially for modular DAC systems with high operational expenses.
    - Supports projects during the ramp-up phase, bridging gaps to full operations.

Program Design Recommendations:

- **Funding:** Allocate adequate resources to support projects of varying scales, from modular to large facilities.
- **Duration:** Commit to multi-year funding (5–10 years) for stability and scalability.
- **Flexibility:** Allow tailored funding mixes (CAPEX, OPEX, or demand-side) to address diverse project needs.
- **Clear Metrics:** Define eligibility and performance criteria for efficient resource allocation.

Impact Priorities:

- Reduce costs by subsidizing O&M and infrastructure.
- Build market confidence through credit purchases and cost reductions.

By combining direct credit purchases, subsidies, and infrastructure guarantees, DOE can stabilize demand, lower costs, and accelerate DAC deployment, ensuring the success of the Regional DAC Hubs program.

12. Which program design features for demand-side support or other non-capex support would be most likely to result in the greatest impact, and why? What overall program characteristics (e.g., total program funding amount, program duration) would give these features of support the most impact? For purposes of this question, when responding please assume that any funds for a new program would come from remaining funds available under the Regional DAC Hubs provision. Feel free to comment on any of the examples below or describe others not mentioned.

a. Establish flexible credit price for different DAC credit suppliers, a single fixed-price, or a lowest-cost approach

b. Require matching credit purchases from voluntary buyers

c. Reward suppliers for reaching sales milestones

d. Give project developers the option to request funding for construction, operations, demand support, and/or other non-capex support programs according to fit the needs of that specific project.

e. Allow DOE to be purchaser of credits, or require DOE be one of many purchasers of equal or greater volume

The most impactful demand-side or non-CAPEX support features should balance simplicity, scalability, and adaptability to diverse project needs:

1. **Avoid Lowest-Cost Approach (Option a):**
   A lowest-cost model risks compromising quality and innovation. Instead, adopt fixed pricing (e.g., 45Q-style) for predictability and fair compensation.

2. **Voluntary Buyer Matching (Option b):**
   Use matching purchases to build market momentum, but designed primarily as a supplemental strategy, particularly for smaller-scale projects.

3. **Rewarding Sales Milestones (Option c):**
   Milestone incentives can encourage scalability but introduce administrative complexity and potential delays. Focus instead on direct operational support or credit purchases to achieve faster, measurable outcomes.

4. **Customizable Funding (Option d):**
   Allow developers to allocate funds to CAPEX, OPEX, or demand mechanisms, addressing specific needs and accelerating deployment.

5. **DOE Credit Purchases (Option e):**
   Federal procurement provides a stable revenue signal, mitigates early-stage risks, and fosters private-sector engagement.

Program Essentials:

- **Duration:** Multi-year (5–10 years) for stability and scalability.
- **Funding Levels:** Support both small and large-scale projects equitably.
- **Clarity:** Streamlined processes and clear criteria minimize delays.

Immediate Priorities:

- Fixed credit pricing for predictability.
- Flexible funding tailored to project needs.
- DOE as an anchor buyer to stabilize early demand.

This approach ensures demand-side support drives deployment, encourages market growth, and establishes a robust DAC industry while minimizing administrative burdens.

13. If not addressed above, please describe the overall program characteristics or other considerations not mentioned that would allow a demand program or noncapex support program to have the greatest impact, and why? For purposes of this question, when responding please assume that any funds for a new program would come from remaining funds available under the Regional DAC Hubs provision.

To enhance the effectiveness of the Regional DAC Hubs program and ensure the scalability and sustainability of the DAC industry, we recommend incorporating mechanisms for cross-project collaboration and sector-wide integration. These initiatives address systemic challenges such as fragmentation, misaligned incentives, and disconnected stakeholders, providing a cost-effective strategy to accelerate deployment and achieve DOE's objectives.

DAC Consortium

A consortium would serve as a centralized platform to connect DAC startups, technology developers, financiers, and storage partners. This structure would enable efficient knowledge transfer, reduce duplication of effort, and strengthen the pipeline of deployable technologies. A pilot consortium funded by DOE could transition to self-sustainability through membership fees or sponsorships. By building a resilient and collaborative ecosystem, this initiative would reduce deployment timelines and increase DAC project success.

Structured Partnership Programs

Formalized programs to integrate DAC developers, partners, and Regional DAC Hubs would ensure that emerging technologies can effectively transition from innovation to implementation. These programs could include matchmaking with DAC technology providers, storage partners, existing DAC Hubs, financiers, and infrastructure developers, enabling faster deployment. For example, a pilot program funded by DOE could connect startups with the TA1 and TA2 DAC Hubs, fostering steady growth and sharing lessons learned. This could even include a third party fund for investing in the startups to encourage transparency and data sharing.

Targeted Engagement and Outreach

Programs designed to connect DAC hubs with industries such as steel, concrete, mining, and oil and gas can accelerate adoption and build pathways for integrating DAC technologies into broader industrial systems, as well as potential buyers and investors into DAC. For example, supporting annual convenings for DAC developers and partners, as well as outreach through DAC-focused tracks at existing industry conferences to expand awareness. Funding these types of DAC convenings could generate significant returns by reaching new audiences, building stakeholder engagement, and attracting industry participation. Transparent outreach efforts would also enhance public trust and confidence in DAC's safety and climate benefits.

To maximize the impact of a demand or non-CAPEX support program under the Regional DAC Hubs provision, consider these key program characteristics:

1. **Program Characteristics:**
    - **Regional Alignment:** Focus on areas with renewable energy and storage infrastructure for cost-effective, sustainable operations.

    - **Scalability Incentives:** Reward cost reductions and efficiency improvements to drive economies of scale and innovation.
    - **Public-Private Collaboration:** Partner with the private sector to share risks, validate technologies, and attract investment.
    - **Standardized MRV:** Implement robust protocols to ensure transparency and build buyer confidence in DAC credits.
2. **Infrastructure and Cost Gaps:**
   Address gaps in CO_2 transport and storage, and provide CAPEX support for FOAK projects to enable scaling. Complement existing incentives like 45Q with targeted funding.

Broader Benefits:

- **Accelerating Deployment:** CAPEX, OPEX, and demand-side support lower costs and de-risk investments.
- **Market Confidence:** Transparent funding builds trust and fosters private-sector engagement.
- **Global Leadership:** Positions the U.S. as a DAC and carbon removal leader.

Enhancing 45Q is a straightforward, effective alternative to a new program, aligning with DAC Hubs goals and leveraging existing frameworks to drive deployment and market growth.

14. What other considerations and tradeoffs should OCED be aware of when evaluating a potential demand-side program or other non-capex program to support commercial DAC facilities? How should OCED incorporate those tradeoffs when evaluating how much, if any, funding from existing DOE authorizations and appropriations to use for DAC demand support or non-capex program?

When evaluating demand-side or non-CAPEX support for DAC facilities, OCED should consider these key tradeoffs and priorities:

1. **Renewable Energy Competition:**
   DAC projects require significant renewable energy. Expanding renewable infrastructure and aligning DAC deployment with energy plans can mitigate competition with other sectors like AI and data centers.

2. **Cross-Sector Balance:**
   Spreading resources across multiple decarbonization goals risks slowing DAC progress. DAC funding should remain distinct and prioritized to maximize impact.

3. **Administrative Capacity:**
   Avoid straining resources by focusing on CAPEX disbursement and leveraging simple, existing mechanisms like enhanced 45Q for demand-side programs.

4. **Regional Infrastructure Needs:**
   Address CO_2 transport and storage gaps by aligning program design with regional capabilities while balancing local and national scaling goals.

5. **Immediate vs. Long-Term Impacts:**
   Prioritize CAPEX and OPEX to enable early projects while phasing in demand-side

programs to support market maturation.

6. **Equitable Funding Allocation:**
   Use transparent criteria to ensure fair resource distribution across diverse projects and regions, building trust among stakeholders.

OCED should focus on immediate CAPEX and OPEX needs, align programs with existing frameworks, and ensure renewable infrastructure expansion to scale DAC effectively. Balancing near-term deployment with long-term growth is essential for impactful resource use.

15. Are there unique equity, environmental, and energy justice considerations and tradeoffs OCED should be aware of when evaluating a potential demand-side program or other non-capex program to support commercial DAC facilities?

OCED must address equity, environmental, and energy justice considerations to ensure DAC programs contribute to equitable decarbonization and foster community trust. Key priorities include:

1. **Renewable Energy Access:**
   Deploy DAC in regions with abundant renewable energy to avoid competing with local needs and promote equitable distribution.

2. **Environmental Integrity:**
   Implement rigorous MRV protocols and contingency plans to ensure CO_2 storage permanence and maintain public confidence.

3. **Community Engagement:**
   Include underserved communities in project planning and direct funding and job creation to these areas to promote equity.

4. **Siting and Land Use:**
   Use equitable siting criteria and conduct environmental impact assessments to avoid burdening marginalized populations.

5. **Workforce Development:**
   Prioritize training for underrepresented groups and communities transitioning from fossil fuels, ensuring high labor standards.

6. **Public Trust:**
   Launch education campaigns highlighting DAC's safety and climate benefits to build acceptance and support.

Integrating these principles into DAC programs will ensure sustainable, inclusive deployment while maximizing social and environmental benefits.

Category 2: Questions related to future DAC market development (Note: all questions are optional)

16. To what extent are today's buyers of DAC credits purchasing voluntarily in anticipation of coming compliance requirements? Which compliance regimes are DAC suppliers and buyers expecting will create demand soonest? What uncertainties and barriers remain to those regimes driving demand for DAC?

Today's buyers of DAC credits are primarily motivated by voluntary commitments tied to corporate sustainability and ESG goals, with anticipation of future compliance playing a secondary role. Potential compliance regimes, such as California's Low Carbon Fuel Standard (LCFS) and state-level policies like the previously-proposed California SB308, could drive significant demand if DAC credits are integrated, with sufficient price signals.

Key Barriers:

1. **Integration Uncertainty:** Lack of clarity on how DAC will fit into compliance markets (e.g., eligibility and accounting standards).
2. **High Costs:** DAC credits are more expensive than alternatives, deterring broader adoption.
3. **Market Scalability:** Limited supply and nascent industry restrict long-term purchasing commitments.
4. **Regulatory Uncertainty:** Slow policy adoption and unclear frameworks hinder confidence.

Recommendations:

- Clarify eligibility criteria and harmonize voluntary and compliance standards.
- Stabilize credit pricing with mechanisms like subsidies or contracts-for-difference.
- Incentivize early voluntary purchases to build momentum ahead of compliance markets.

Voluntary commitments currently dominate demand, but clear frameworks and incentives can unlock the potential for compliance-driven growth. DOE should prioritize aligning policies and supporting early adoption to foster a robust DAC market.

17. In what ways could a DAC demand program most effectively bridge today's voluntary and "pre-compliance" demand with demand from future compliance based or long-term government procurement programs? Would tradeoffs exist between a demand program designed to achieve those goals versus a program designed around the needs of the current and next DAC projects?

A well-designed DAC demand program can bridge today's voluntary and "pre-compliance" demand with future compliance-based or government procurement markets by aligning standards, stabilizing revenue streams, and supporting early deployment. Key mechanisms include:

1. **Public Procurement**: Governments acting as anchor buyers can reduce risks, attract voluntary buyers, and set a precedent for compliance markets.

2. **Incentives for Early Adopters**: Tax benefits, co-funding, and subsidies can de-risk purchases and expand participation.
3. **Transitional Frameworks**: Aligning voluntary market standards (e.g., MRV) with compliance requirements ensures compatibility and smooth market entry.
4. **Early Deployment**: Demonstrating feasibility and scalability through active projects builds market trust and prepares for compliance-driven demand.

Tradeoffs include balancing near-term support for early-stage projects with readiness for long-term compliance needs. A dual-focused strategy combining CAPEX and OPEX support for current projects with incentives for compliance alignment can ensure both immediate impact and sustainable growth. The program should prioritize deployment now to establish a strong foundation for future markets.

18. To what extent would a demand program based on a limited duration of funding (i.e., not a permanent or ongoing program) be effective or ineffective in signaling to investors and prospective DAC credit purchasers the potential for long-term demand for DAC? What would success look like, given there are limited resources currently available?

A limited-duration demand program can effectively signal long-term confidence in DAC if designed strategically to address immediate barriers and lay the foundation for sustained demand. It can also stimulate immediate demand by incentivizing immediate action from buyers to secure lower-priced tonnage and enable access to future volumes. Key considerations include:

1. **Effectiveness:**
    - **Market Signal:** A well-funded, temporary program ($600M–$800M) demonstrates government commitment, boosting investor and buyer confidence.
    - **Early Deployment:** Targets early-stage projects to catalyze private investment and reduce costs through innovation and economies of scale.
    - **Leadership:** Positions the U.S. as a leader in CDR markets, paving the way for voluntary and compliance growth.
2. **Success Metrics:**
    - Enable projects to reach Final Investment Decision (FID) and operational status.
    - Attract private-sector investment by leveraging federal funding.
    - Establish reliable MRV standards to build market trust.
    - Create pathways to integrate voluntary and compliance markets post-program.
3. **Challenges:**
    - Short timelines (4–5 years) may exclude smaller or FOAK projects needing longer development.
    - Perceived instability could deter investors seeking market longevity.
    - Limited funds might favor established developers over diverse, smaller-scale projects.

4. **Recommendations:**

    - Extend timelines to 8–10 years for better alignment with DAC project cycles.
    - Pair CAPEX and OPEX funding with demand-side incentives to ensure viability.
    - Develop phased transition plans to long-term compliance frameworks.
    - Allocate resources equitably across project scales to foster competition and diversity.

With a focus on deployment, private-sector engagement, and integration into compliance markets, a temporary program can drive significant progress while mitigating risks of its limited duration. DOE should prioritize these strategies to maximize impact and establish a robust DAC market.

19. How could demand support deployed today for the next round of DAC projects more effectively lead to subsequent deployments and reductions in the cost of DAC?

Demand support deployed today can accelerate DAC deployment, reduce costs, and foster a self-sustaining market. Key strategies include:

1. **Driving Deployment:**

    - Long-term credit purchase agreements and government procurement provide stable revenue, boosting investor confidence and market credibility.
    - Investments in shared infrastructure, like CO_2 transport and storage hubs, reduce barriers and enable broader deployment.
2. **Reducing Costs:**

    - Economies of scale lower per-ton capture costs and encourage component production at reduced capital expense.
    - Incentives drive technological advancements, improving energy efficiency and operational processes.
3. **Catalyzing Growth:**

    - Price guarantees and minimum credit prices protect developers from volatility and encourage scaling.
    - Corporate demand aggregation fosters economies of scale and broader market participation.
    - Standardized MRV protocols ensure credit quality and enhance market trust.

Broader Impacts:

- Improves financing conditions by reducing investment risks.
- Positions the U.S. as a global leader in DAC technology through early deployment and cost reductions.

DOE should prioritize long-term offtake agreements, price stabilization, and MRV standardization to drive growth and efficiency in the DAC market.

20. What selling price for credits or cost reductions in generating credits would allow the US-based DAC industry to no longer need project-level funding to subsidize construction and operations?

21. How does the selling price for credits or total subsidy (including tax benefits, grants/cooperative agreements for upfront capital cost, and any potential demand-side subsidy) per unit of emissions captured compare to the social cost of carbon?7 Are there any barriers to data collection or analysis for this comparison?

We would like to firstly point out that it is not clear that the social cost of carbon today (SCC) is a useful benchmark/metric for these purposes – since DAC provides a long-term solution for what will be an inevitably increasing SCC over time . Accordingly, we should note that the cost of DAC credits ($250–$600/ton, exceeding $1,000/ton for FOAK projects) far exceeds the Social Cost of Carbon (SCC), estimated at $50–$185/ton. Subsidies like 45Q ($180/ton) help but are insufficient to close this gap, underscoring the need for continued financial support.

Barriers to Alignment:

- **Cost Variability:** Costs differ by technology, scale, and location, complicating SCC comparisons.
- **Data Gaps:** Limited lifecycle and operational data hinder accurate cost assessments.
- **Dynamic SCC Estimates:** Varying climate models and policy assumptions add uncertainty.
- **Market Fluctuations:** Voluntary credit prices are inconsistent, complicating alignment.

Recommendations:

- **Standardize Reporting:** Develop uniform carbon accounting and lifecycle analysis frameworks.
- **Enhance Subsidies:** Increase 45Q values and add complementary demand-side incentives to narrow the gap.
- **Data Transparency:** Invest in monitoring and reporting to build a reliable dataset for cost analysis.
- **Innovation:** Support R&D to improve efficiency, lower costs, and integrate co-products like green hydrogen.

Aligning DAC costs with the SCC requires scaling deployments, advancing innovation, and sustained financial support. DOE should prioritize these efforts to make DAC a viable, impactful climate solution.