CALDAC Statement of Project Objectives

The Statement of Project Objectives (SOPO) outlines the tasks to be completed over the course of the project and was submitted to DOE on March 13, 2023. The SOPO will change slightly during the award negotiation process. A final version will be posted when negotiation is complete (anticipated in March, 2024).

Berkeley Law

Center for Law, Energy,
& the Environment

STATEMENT OF PROJECT OBJECTIVES

A. OBJECTIVES

This project will undertake a comprehensive assessment of the technical, social and governance feasibility of establishing a **C**ommunity **Al**liance for **D**irect **A**ir **C**apture (**CALDAC**) in California. This innovative proposal invites the local community to be the center of DAC Hub development. The feasibility assessment will include two intersecting and interconnected elements:

- Development of the DAC Hub structure and assessment of the technical feasibility of the DAC Hub, including technology partners, location, business model, and CO_2 storage/utilization/conversion option(s), and
- Assessment of the social and governance feasibility of an innovative, community-led ownership model and community benefits plan that engages local stakeholders as core partners.

B. SCOPE OF WORK

We will address both project objectives through the course of the project. The diverse team that is assembled will co-produce research questions and scenarios related to the social, environmental, and technological implications of a DAC hub. During Phase 0a, we will assess candidate DAC and CO_2-to-products technologies both individually and as an integrated hub system to ensure that the DAC hub is anchored in strong technical and technological capacity. This assessment will provide inputs to the finalized DAC Hub concept and conceptual design, Technology Maturation Plan, Life Cycle Assessment, Technoeconomic Analysis, and pre-FEED study. We will work with our community partners to conduct outreach, engagement, and education on DAC; establish a compensated Community Oversight Council; and develop a set of community-vetted criteria and goals for DAC hub design, development, and operation. These activities will inform preliminary hub design, integration, location, and ownership decisions. Completion of a feasibility assessment that meets both technical and social criteria tasks is a go/no go decision point to advance to Phase 0b.

During Phase 0b, we will continue to support co-creation of the hub design and development with technology partners and the Community Oversight Council. Based on the hub design developed in Phase 0a, we will continue the technical feasibility assessment for scaling the hub capacity from initially at least 50,000 tonnes per year (TPY) to at least 1 million TPY. This scaling will be completed and evaluated alongside community-developed performance criteria. In Phase 0b, we will work with the Community Oversight Council to co-produce the Community Benefits Plan. The Plan will be developed through robust engagement with labor, local government, environmental justice, and other stakeholders. The community vision, goals, and values for the DAC hub developed in Phase 0a will be the foundation of the CBP. We will work with the hub owner(s) to develop a business and financial plan that delivers community benefits in alignment with the community vision, goals, and criteria for a regional DAC hub.

C. TASKS TO BE PERFORMED

Task 1.0 – Project Management and Planning (Leads: UCB and LBNL)

Subtask 1.1 – Project Management Plan

"The Recipient shall manage and direct the project in accordance with a Project Management Plan to meet all technical, schedule and budget objectives and requirements. The Recipient will coordinate activities in order to effectively accomplish the work. The Recipient will ensure that project plans, results, and decisions are appropriately documented and project reporting and briefing requirements are satisfied.

The Recipient shall update the Project Management Plan 30 days after award and as necessary throughout the project to accurately reflect the current status of the project. Examples of when it may be appropriate to update the Project Management Plan include: (a) project management policy and procedural changes; (b) changes to the technical, cost, and/or schedule baseline for the project; (c) significant changes in scope, methods, or approaches; or (d) as otherwise required to ensure that the plan is the appropriate governing document for the work required to accomplish the project objectives.

Management of project risks will occur in accordance with the risk management methodology delineated in the Project Management Plan in order to identify, assess, monitor and mitigate technical uncertainties as well as schedule, budgetary and environmental risks associated with all aspects of the project. The results and status of the risk management process will be presented during project reviews and in quarterly progress reports with emphasis placed on the medium- and high-risk items."

Subtask 1.2 – Business Plan

"The Recipient shall develop a Business Plan for the project. The Business Plan shall encompass Commercial Feasibility and Business Case Analysis; Key Contracts, Permits, and Agreements; Preliminary Site Selection; Market Analysis; Feedstock, Supplies, and Offtake Arrangements, and the DAC Hub Capacity Build-Out Plan."

Subtask 1.3 – Financial Plan

"The Recipient shall develop a Financial Plan that presents a viable plan to obtain funding for the entire non-DOE share of the total project cost and identifies all sources of project funds."

Subtask 1.4 – Technology Maturation Plan

"The Recipient shall develop a Technology Maturation Plan (TMP) that describes the current technology readiness level (TRL) of the proposed technology/technologies, relates the proposed project work to maturation of the proposed technology, describes the expected TRL at the end of the project, and describes any known post-project research and development necessary to further mature the technology. For TA-1, the initial TMP is due with the Phase 0a "Decision Point Application" and should be updated as needed throughout the project period of performance. For TA-2 and TA-3, the initial TMP is due 90 days after award and should be updated as needed throughout the project period of performance. A final TMP should be submitted within 90 days of completion of the project."

Subtask 1.5 – Community Benefits Plan

"The Recipient shall develop a CBP Development Proposal during Phase 0a. The Recipient shall develop a CBP during Phase 0b."

BUDGET PERIOD 1 (PHASE 0a – PRE-FEASIBILITY)

Task 2.0 – Hub Design and Development (LBNL, EPRI, UCB, Technology Providers)

Subtask 2.1 – Assessment of DAC Technologies (LBNL, EPRI, Technology Providers)

We will work with each DAC technology to collect or estimate inputs for the Technology Maturity Plan, Life Cycle Assessment, and Technoeconomic Analysis. We will request that companies provide state-point data, details, updates on technology developments, and any available process flow diagrams or schematics. We will start the assessment with our four partner companies: Mosaic, Capture6, Origen, and AirMyne. The assessment will include descriptions of technology state of development and scale, which is essential for understanding design flexibility, scaling uncertainty when extrapolating data, and for determining appropriate technology performance milestones. The project team will also work with other DAC technology providers during the pre-feasibility study to see whether participation in the hub might be considered. Once an inventory is developed for the DAC technologies, LBNL and EPRI will verify the inventory to ensure it provides detail at relevant operating conditions to conduct subsequent process modeling, and environmental and economic assessments.

Subtask 2.2 – Assessment of CO_2 to Products Technologies (LBNL, Technology Providers)

As in Subtask 2.1, we will gather or estimate inputs for the Technology Maturity Plan, Life Cycle Assessment, and Technoeconomic Analysis from each CO_2 to Products technology: Blue Planet and Carbon Built. LBNL will compile information in an inventory and conduct analysis to ensure each technology has a complete energy and mass balance for relevant deployment scales, with an eye towards integrated operations that maximize heat, hydrogen, power and mass transport efficiency and cost within the DAC Hub physical infrastructure. Additional technologies will be assessed as they become available thanks to the modular testbed approach used by the hub. Such an approach can quickly adapt to screening new technologies that are ready for testing and evaluation in a skid-like workflow at scale with integrated data collection and analysis. The project team will also work with other CO_2 to Products technology providers during the pre-feasibility study to see whether participation in the hub might be considered. Once an inventory is developed for the CO_2 to products technologies, LBNL will verify the inventory to ensure it provides detail at relevant operating conditions to conduct subsequent process modeling, and environmental and economic assessments.

Subtask 2.3 – Community Guided Project Design (UCB, LBNL, EPRI)

We will work with the CALDAC Community Oversight Council (see Task 5.3) and technology providers to prepare scenarios for the DAC Hub design. We will evaluate these scenarios against the performance objectives of the solicitation (i.e., minimum capacity of at least 50,000 tonnes CO_2 annually captured from the atmosphere (50,000 TPY) for the pre-FEED study to be completed in Phase 0b) and community vision, goals, and criteria of hub design. We will produce data tables with preliminary estimates for the operations of the hub. We will prioritize scenarios according to synergy between hub performance goals, TRLs, and community priorities. Based on this process, we will select anchoring technologies going forward that will serve as the initial baseline for the development of the CALDAC Technology Maturation Plan.

Inputs to guide hub designs which will be evaluated in Task 3 will be derived from the community engagement process. Inputs may include targets for financial performance, water consumption, or annual volumes of stored CO_2. Many possible hub configurations may emerge from the anchor and alternative technologies evaluated in Tasks 2.3 and 2.4, and only hub designs that can meet the Project Design Basis, which reflect the needs of the hub owner and community, will be explored in the feasibility study.

Task 3.0 – Hub Resources and Analysis (EPRI, LBNL, AECOM, UCB, CES, Fresno State, Rondo, Technology Providers)

Subtask 3.1 – Preliminary DAC Hub Design (UCB, LBNL, EPRI, AECOM)

We will develop a preliminary hub design that conforms to community developed vision, goals, and criteria (developed in Task 5.0 and associated subtasks). Selected DAC Hub technologies and CO_2 to Products technologies identified in Task 2.0 will provide the starting point for assessment of resource requirements (i.e., energy, land, water, etc.). These preliminary DAC hub designs will be shaped at first based on individual technology data tables and the overall Project Design Basis, and advanced as process modeling and simulation efforts offer more robust data on equipment requirements, operation cycles, and material and energy storage and consumption.

Subtask 3.2 – Energy: Sources of Electricity and Thermal Energy (UCB, Rondo)

Based upon the energy usage of selected technologies, we will calculate the amount of clean electricity sources needed to support an initial buildout of 50,000 TPY. Evaluation of electricity sources will be informed by the Community Oversight Council (developed in Subtask 5.4). The evaluation will include consideration of BiCRS, renewable electricity generation, and energy storage. We will prepare a detailed planning and optimization study of renewable power and heat sources for initial capacity. The BiCRS plants that are co-hosting the DAC Hub will provide roughly enough power and heat to satisfy the initial removal capacity of at least 50,000 TPY. We will also consider the delivery of power, heat, syngas, water to the CO_2 to Products facilities in order to maximize energy and carbon capture/conversion efficiency. This task will be directly informed by the process modeling and simulation efforts that may start with individual technologies but will ultimately evolve to capture synergistic effects of colocation that could influence energy needs.

Subtask 3.3 – Water Management: Requirements and Availability (Fresno State, LBNL, UCB)

The team will develop information regarding unconventional water sources located in the southern San Joaquin Valley that may be available for use with the three sites and related processes requiring water. Given drought considerations, CALDAC will prioritize modular optimized approach to circular water management that relies on unconventional water sources. Potential sources of water include, but not limited to surface waters available for agricultural and domestic uses; agricultural drainage waters; dairy wash waters; food processing facilities such as wineries, tomato paste, cheese, and juice plants; fresh produce processing plants; municipal wastewater treatment plants; groundwater having domestic and agricultural users; petroleum industry-produced water; and brackish water in groundwater aquifers. Based upon information received regarding technology water usage and quality needs, we will evaluate the availability candidate water sources according to: (1) source type, (2) volume, (3) quality and treatability, (4) location, (5) estimated cost at the source and transport costs, and (6) other special considerations including treatment pertaining to each source type. Importantly, the cost delivered to a DAC process is a function of the amount of water required and the distance between the water source and the DAC facility. We will also explore secondary usage or disposal of wastewater from DAC facilities.

Subtask 3.4 – CO_2 Purification (AECOM)

We will assess CO_2 purification options for an initial buildout of 50,000 TPY. In an ideal situation, CO_2 produced by different DAC technology providers will be combined into a single stream to minimize redundant equipment and cost. The choice of purification technologies will be dictated by produced CO_2 purity as well as the purity needed for downstream operations (e.g., geologic sequestration). Options include simple dehydration and compression to cryogenic distillation. For the 50,000 TPY feasibility study, priority will be placed on pre-engineered, turnkey systems rather than greenfield design, but system optimization with other Balance of Plant (BOP) equipment will be explored.

Subtask 3.5 – Hub Layout and Land Use (AECOM, EPRI)

Preliminary design for the 50,000 TPY hub layout will consider optimal locations for centralized equipment (e.g., CO_2 purification), air flow, CO_2 depletion, CO_2 conversion, energy and water/wastewater flow, and interdependencies between DAC providers. Hub activities that require transportation of material into or out of the hub will be located to minimize localized impacts. The hub's footprint will also be minimized while retaining maneuverability throughout the site for operation and maintenance activities and to adhere to engineering best practices and regional codes and requirements.

Subtask 3.6 – Host Site Modifications (CES, AECOM)

Several opportunities exist for hub cost reduction by leveraging existing infrastructure and equipment at the host sites. The objective of this task is to identify such opportunities, as well as characterize the cost and timeline for necessary modifications. Modifications may range from changes to the CO_2 pipelines and injection site, to relocation of biomass onsite to accommodate DAC air contactor distribution, to adjustments to existing and new safety and utility requirements.

Subtask 3.7 – Integration and Hub Design: Connections and Synergies (LBNL, AECOM, EPRI)

We will identify opportunities for shared equipment, synergistic thermal and material flows, and overall hub optimization following the initial development of a hub design, and as new DAC and CO_2-to-products technologies are identified. We will develop process flow diagrams for each technology according to the company informed guidance and state tables for a feasible capture scale, and then scaled based on the individual technology's potential contribution to meeting the hub CO_2 capture capacity requirements as well as the Project Design Basis. Following this first assessment, opportunities for technology integration will be carefully evaluated. Each opportunity may come with an advantage at either the technology or hub level, and tradeoffs must be weighed accordingly. In some cases, decisions may be simple and rational engineering choices that lower risk of unexpected shutdowns. In other cases, there may be a tradeoff among profitability, energy, land and water efficiency, sharing transportation equipment and CO_2 processing equipment, minimizing socio-environmental impacts, flexibility and redundancy.

Subtask 3.8 – Preliminary Life Cycle Analysis (EPRI, LBNL, AECOM, Technology Providers)

The team will conduct a preliminary life cycle analysis (LCA) of the DAC Hub at the initial capacity (at least 50,000 TPY CO_2) and final capacity (at least 1 M TPY CO_2) in accordance with Appendix D of the FOA. Analyses of the energy and material inputs and outputs from each process will be integrated, resulting in a high-level carbon balance of all components, processes, and co-products derived from CO_2 not stored underground.

The team will follow NETL CO_2U LCA guidance for developing an LCA for each component technology and will construct an attributional LCA inventory based on energy and material inputs from anchor DAC technologies and CO_2 disposal pathways, including components such as pipelines and underground storage. We will estimate direct and indirect greenhouse gas emissions and criteria air pollutants based on the operation of systems, and the source of plausible local energy and feedstocks, using emission factors reported in the CA-GREET model and literature. Sensitivity analysis based on factors such as carbon intensities of electricity and heat sources will be considered to understand the range of expected outcomes, and will be refined as the sources of energy and feedstocks are known. All results will be normalized to a functional unit of 1 kg of CO_2 removed from the atmosphere and permanently stored. Major uncertainties stemming from the DAC technologies, the manufacturing of novel materials, and their hub-level integration will be discussed in a summary report.

Subtask 3.9 – Geologic Storage Options and Available Capacity (LBNL, CES, AECOM)

Historic oil and gas exploration and production has identified widespread contingent storage resources in the area of each potential CALDAC site. The three BiCRS sites have credible plans for development of subsurface storage that will offer additional capacity for the >1 M TPY CO_2 removed from air. Detailed subsurface site characterization is underway for the Delano site, with plans to develop and submit a Class VI UIC permit application mid-2023. CES is considering joint storage development for the Mendota and Madera sites, using a 2020 Class VI permit application as the starting point. Working with CES and other potential storage providers, the CALDAC team will assess the planned storage locations and will monitor progress towards development, characterization, and permitting activities, relative to the capacity needed for a minimum of 12 years of DAC Hub operation.

The team will also review potential obstacles to storage development and provide mitigation plans. For example, pore space ownership in the vicinity of each site is fragmented relative to the size of prospective CO_2 footprints resulting from storage. One of the three sites is also in the vicinity of residences. Due to these factors, the team will identify a suite of potential locations for storing the CO_2 from each site that provide options meeting community preferences expressed in the Project Design Basis developed in Subtask 2.3 and gaining pore space access. The team will generate and elicit community perspective on each location, including transportation of CO_2. The team will open pore space access discussions with the owners of each location. Based on the results, the team will work with the site hosts to optimize storage locations for CALDAC. The team will consider existence of legacy wells as a secondary factor in down selection.

Task 4.0 – Environment, Health and Safety (LBNL, PSE, Fresno State AECOM, UCB)

Subtask 4.1 – Environmental Health and Safety Risk Analysis (PSE, Fresno State, LBNL, UCB)

4.1.1 – Air (PSE)

We will assess risks from air emissions based on data on all potential or incidental air emissions provided by DAC, CO_2 to products, energy supply and storage providers, and the host site operator (CES). We may also request methods used to develop underlying emissions rates, estimate magnitude of emissions, and/or model ambient air concentrations. A subset of the Project Team will independently review data via approaches outlined in Technical Volume (see 'Environmental Impacts and Mitigation - Air Quality'). We will assess potential hazards to human health and the environment for the air pollutants identified by technology providers and the host site operator, including associated transformation and degradation byproducts We will compile chemical-specific physical, chemical and toxicological properties (e.g., volatility, flammability, explosivity, corrosivity, biodegradation and bioaccumulation potential, acute and chronic toxicity) and associated environmental and/or health-based guidance values from publicly available state, federal, and international screening and authoritative databases and the peer-reviewed literature. We will examine similar substances or class of substances for any air pollutants lacking information on potential health effects or ecotoxicity shall be evaluated. Depending on data availability, emissions rates may be used to model ambient air pollutant concentrations and evaluate potential health risks and impacts. Findings from the independent review of potential air quality risks and impacts can be used to inform exploration of community-focused air monitoring approaches for the build phase and to co-develop a community air monitoring plan with the Community Oversight Council.

4.1.2 – Water (Fresno State, UCB, LBNL)

The availability of water resources for the proposed technologies will be evaluated in Subtask 3.3. This task will work closely with that effort but will focus on any potential changes, deleterious or positive, impacts on water quality resulting from DAC Hub activities. The rerouting and repurposing of water resources could potentially have positive benefits for water quality by providing a use for lower quality waste waters. However, any change in water resource utilization needs to be examined at a system level. In addition, we will evaluate potential water quality impacts of all DAC Hub activities, e.g. potential impacts to groundwater from geologic carbon storage activities, any effluent or waste waters that need disposal, changing utilization of groundwater (fresh and brackish). The impacts will be assessed in the context of regional water quality but will also focus specifically on domestic and municipal wells and water sources in the vicinity of the Hub site(s).

4.1.3 – Other Risks (LBNL, PSE)

Air and water impacts are expected to be the most likely concerns associated with the Hub development. However, in conjunction with our community partners we will also assess other potential negative or positive environmental impacts of the proposed project including impacts on traffic, noise, light pollution, or local wildlife.

Subtask 4.2 – Safety, Security, and Regulatory Requirements (AECOM, UCB)

The larger and more established participants in CALDAC (i.e., UCB, LBNL, EPRI, AECOM) have an established safety culture and history which can be readily communicated and adapted to the unique requirements of the Hub. These larger entities can help guide the newer organizations, leading by example to assist the development of a safety culture and security standards for the technology providers. The site, as is typical of any industrial facility, will have controlled access. AECOM has experience with both physical protection and cybersecurity of sensitive sites, construction sites, and operating facilities that will be adapted for the host site facility. Permit applications will not be sought during the feasibility study, but the team will develop a list of the permits required as well as the applicable regulatory standards. Contact with the relevant regulatory agencies will be initiated where feasible. Priority will be given to requirements that have lengthy review and approval processes and those that require input from aligned community groups.

Task 5.0 – Community Partnership and Benefits (UCB, LBNL, Project 2030, Data for Progress, Carbon180, Valley Onward, CSU Bakersfield)

Subtask 5.1 – Community Outreach and Engagement (Data for Progress, Carbon180, UCB, LBNL, CSU Bakersfield)

We aim to have community groups as thought partners in this feasibility effort. Carbon180 in consultation with LBNL, will administer grants to community-based organizations to support staffing, capacity building, and other resources to ensure that they have the staff resources and technical capacity to engage. Valley Onward will support community outreach and engagement with labor and workforce agencies throughout the project. We will conduct a series of roundtables and convenings to engage residents, stakeholders, and community organizations in DAC hub design. We will conduct roundtables at locations and times that are conducive to broad participation. We will provide compensation for participants and other services (e.g., food, childcare) to increase accessibility.

Subtask 5.2 – Carbon Removal Curriculum (Carbon180)

To increase accessibility for community members and community-based organizations to engage in the DAC process, Carbon180 will host sessions to deliver their carbon dioxide removal curriculum. The curriculum is designed to support informed community decision making around DAC engagement. The curriculum empowers citizens and communities to make decisions about whether and how they engage with DAC technology, including hub development.

Subtask 5.3 – Establish Community Oversight Council (Carbon180, UCB, LBNL, Data for Progress, Valley Onward, Project 2030)

We will establish a Community Oversight Council that includes representatives of community-based organizations, environmental justice organizations, labor and workforce representatives, and residents. UC Berkeley will work with local organizations to develop a facilitation and convening strategy for the Council. All members of the Council will be compensated for their participation. We will facilitate meetings between the Community Oversight Council, technology providers, and site owner(s) to develop a shared set of criteria for hub design, development, and performance.

Subtask 5.4 – Develop Community Vision and Goals for Hub (UCB, LBNL, Valley Onward)

The Community Oversight Council will work with technology providers, UC Berkeley, and LBNL to develop a community vision and goals for a DAC Hub. These criteria will be used to guide the feasibility assessment and design principles. We will identify and collect community-relevant data to inform the design process and to monitor, track and verify social and environmental goals. This could include various climate and resource needs data related to CALDAC (water, energy, and air), as well as data in line with the federal government's Justice40 initiative. We will establish baseline data and data transparency processes to ensure timely sharing of project performance data in an easily understandable and regionally-relevant manner with the public. We will also test and verify the effectiveness and possible environmental and social footprint of technologies that could be included as part of the DAC technology portfolio (included in Task 2 and associated subtasks).

Task 6.0 – Hub Ownership (UCB, LBNL, Data for Progress, Project 2030, Carbon180, Valley Onward)

Subtask 6.1 – Review of Possible Ownership Structures (Project2030, LBNL, UCB)

We will prepare a literature review of public, community, and cooperative hub ownership models that include a comparison of the characteristics of different ownership models, including enabling legal and regulatory actions. We will explore the feasibility and legal and regulatory steps needed to establish a Public Authority to oversee the business model, operations and financing of a DAC hub. A Public Authority would operate the DAC hub as a public good – one that maximizes safety and the strongest environmental standards while minimizing costs.

Subtask 6.2 – Identify Hub Owner(s) (UCB, LBNL)

Based on the review of ownership models, engagement with technology providers, site owner(s), and the Community Oversight Council, we will select an ownership model and identify a hub owner or owners. We will also identify needed steps to establish an ownership structure in Phase 0b, including any transitional or intermediate steps. We will evaluate ownership models for alignment with community vision, goals, and criteria.

Task 7.0 – Phase 0a Topical Report and Decision Point Preparation (UCB, LBNL)

The team will prepare and submit a "Decision Point Application" directly to the DOE Project Officer and the DOE Contract Specialist no later than forty-five (45) days prior to the end of Phase 0a – Pre- Feasibility. In addition, a Topical Report documenting the results of work completed to date will be submitted as a separate document along with the Decision Point Application. The Decision Point Application shall include the following information:

- A report on progress towards meeting the objectives of the project, including any significant findings, conclusions, or developments.
- DAC and CO_2 conversion Technology Maturation Plans
- Preliminary Life Cycle Analysis
- CBP Development Proposal (CBPDP)
- A detailed budget and supporting justification for the upcoming Phase 0b – Feasibility. The budget should confirm a previously submitted and negotiated budget, or shall be a revised budget if a reduction of funds is anticipated, or if a budget for the upcoming phase was not approved at the time of award.
- A description of the Recipient's plans for the conduct of the project during the upcoming scope of work.

BUDGET PERIOD 2 (PHASE 0B – FEASIBILITY)

Task 8.0 – Technology Description and Scale-Up Potential (EPRI, LBNL, Technology Providers)

This task will be a continuation and further maturation of the efforts conducted in Task 2, but with a shift in emphasis on conducting scale-up feasibility and design scenarios to at least 1 M TPY for the DAC hub for all selected DAC and CO_2 to products technologies that pass through the Go/No-Go process in Phase 0a. This will include evaluating the community-based priorities and perspectives around the deployment of these technologies at the scale of the hub to be built and operated. The assessment will also include descriptions of technology state of development and scale, which is essential for understanding design flexibility, scaling uncertainty when extrapolating data, and for determining appropriate technology performance milestones. Once an inventory is developed for the DAC and CO_2 to products technologies, LBNL and EPRI will conduct additional analysis to verify inputs and ensure the inventory and technologies are described with enough detail at relevant operating conditions to conduct subsequent process modeling, and environmental and economic assessments. We will produce data tables with the next round of estimates for the operations of the hub. Prioritization of those designs and related technologies that maximize the synergy between hub performance goals, TRLs, and community priorities will be used to rank the different scenarios evaluated.

Based on this process, we will select the final anchoring technologies going forward that will serve as the foundational engineering design basis for the hub and the finalization of the CALDAC Technology Maturation Plan.

Task 9.0 - Finalize DAC Hub Concept (UCB, LBNL, EPRI, AECOM, Fresno State, CES, Rondo, Technology Providers)

Subtask 9.1 – Final DAC Hub Design (UCB, LBNL, EPRI, AECOM)

We will develop a final DAC hub design for a capture capacity of at least 1 M TPY. The design will be informed by the knowledge gained through the development and technical and community vetting of hub designs at the 50,000 TPY scale, the life cycle assessment, technology maturity plans for each technology, and technoeconomic analysis. This will include qualitative information, such as the effects of scale up on the host site and local communities. We will evaluate additional effects of scale identified in the Balance of Plant. This could include the potential change in technology contribution to capture and opportunities for system integration or improved ancillary equipment performance that are possible at a larger scale. We will work with the Community Oversight Council to assess final hub design and evaluate options relative to community goals, vision, and criteria, with emphasis on concerns resulting from operation at a larger scale. The hub design will include guidance on the implication of scale that is specific to the region of study, that may extend beyond a 1 M TPY capacity. This will provide the basis for analysis of resource requirements (i.e., energy, land, water, etc.) and energy source(s) for the selected DAC technology(ies), as well as CO_2 to Product technologies.

Subtask 9.2 – Resource Planning: Energy, Water, Layout and Land Use (UCB, Fresno State, LBNL, CES, AECOM, EPRI, Rondo)

We will complete resource planning for initial buildout (50,000 TPY) and final buildout (1 M TPY) to feed into BOP for final capacity as described in Task 3.0 and associated Subtasks. In Phase 0b, we will focus attention on the increased electricity and thermal energy demand with a buildout to 1 M TPY. Reliance on intermittent sources will depend on smart grid integration and optimization of supply and demand as well as build-out of energy storage solutions. We will evaluate potential power supply by hydrogen via fuel cell technology and storage via Rondo Heat Battery. We will also continue to evaluate unconventional water sources located in the southern San Joaquin Valley that may be available for use with the three identified carbon dioxide capture sites and related processes requiring water.

Subtask 9.3 – Preliminary Life Cycle Analysis (EPRI, LBNL, AECOM, Technology Providers)

We will continue activities on Life Cycle Analysis begun in Phase 0a. The LCA inventory will be updated for the 1 M TPY scale, and any new life cycle phases associated with the final DAC hub design will be evaluated following Appendix D of the FOA.

Subtask 9.4 – Integrated DAC System pre-FEED Study (i.e., Initial DAC Hub Capacity) (AECOM, EPRI, LBNL, Technology Providers)

The pre-FEED for the initial capacity DAC Hub will include key capital equipment for each DAC technology and shared supporting infrastructures such as heating and cooling, water, CO_2

purification, compression, and transportation. The general design and size of the equipment will be based on heat and material balances, heating and cooling duties, and power requirements provided by anchor DAC partners and key vendors. If partner companies do not have complete process flow diagrams, the analysis will derive these data from theoretical heat and mass transfer calculations. We will conduct process modeling using software such as Aspen. We will normalize key metrics, including capture rates and efficiencies, land use, feedstock consumption, and waste production relative to captured tonnes of CO_2, both for each subcomponent and the entire DAC Hub.

This task will result in: The pre-FEED final report for the initial DAC Hub following the guidance in Appendix L; and the completed relevant Hub Data Tables, which are expected to be for sorbent, solvent- and mineralization-based capture, the synthesis of value-added organics, and the production of inorganic materials. We will combine the results from the pre-FEED with the pre-LCA for a range of electricity and thermal production carbon intensities to calculate the cost of CO_2 abated, and the levelized cost of electricity.

Subtask 9.5 – Hub Balance-of-Plant (BOP) Conceptual Design (UCB, LBNL, EPRI)

We will identify the conceptual design for the mature DAC Hub at its final design capacity based on requirements of the Project Design Basis. This will include identifying and evaluating options for all common systems and utilities including electricity, thermal energy, cooling, water, waste treatment, and CO_2 transportation. To develop a process flow diagram, we will consider plausible scenarios for collocation siting and integration of anchor technologies with each other, with pipelines, water, and CO_2 injection infrastructure. In doing this we will consider heat and mass balances for each process at scale and for the integrated hub at the final capacity DAC Hub. Details on the pipeline and the geologic carbon storage system will be informed by previous and ongoing work conducted by CALDAC's site host CES and their partners.

Subtask 9.6 – Geologic Storage Options and Available Capacity (LBNL, CES, AECOM)

The team will continue engagement with the pore space owners for each of the storage locations selected in Phase 0a (Subtask 3.9). We will work with CES and potentially other hosts of storage locations associated with each CALDAC site to provide sufficient for 12 years of operation. All work will be conducted with full consideration of parameters and preferences developed by community stakeholders in Subtask 3.9, and the feasibility and magnitude of legacy well corrective actions. For each of these the team will develop preliminary plans for CO_2 monitoring, reporting, and verification. The status of this aspect of storage along with that of each of the other components of a Storage Field Development Plan according to Appendix U of the FOA, including preliminary Authorizations of Expenditures for the proposed project wells in the cost section will be developed and submitted 90 days prior to project completion.

Subtask 9.7 – Business Development and Financial Plan (LBNL, AECOM)

An initial market assessment will estimate the required selling price (RSP) for each CO_2 conversion product derived from anchor DAC technologies. Key material and energy inputs as well as overhead estimations will be based on the developed BOP conceptual design. A plausible range of RSP will be derived from identified uncertainties. Commercial viability for each product will be conducted by assessing its market price and gross market volume at present and in the near future when the proposed DAC Hub can be scaled to 1 M TPY CO_2. We will also assess potential for credits for carbon removal as a revenue generation mechanism.

Task 10.0 – Environment, Health and Safety (LBNL, PSE, Fresno State, AECOM, UCB)

EH&S risk analysis activities under Task 10 will include continuation of activities outlined in Task 4 and will lead to a complete EH&S risk analysis.

Subtask 10.1 – Environmental Health and Safety (EH&S) Risk Analysis (PSE, Fresno State, LBNL, UCB)

EH&S risk analysis activities under Subtask 10.1 will include continuation of activities outlined in Subtask 4.1 and will lead to a completed EH&S risk analysis.

10.1.1 – Air (PSE)

EH&S risk analysis activities focused on air emissions under Subtask 10.1.1 will include continuation of activities outlined in Subtask 4.1.1 and will lead to a completed EH&S risk analysis component focused on air emissions.

10.1.2 – Water (Fresno State, LBNL, UCB)

Activity on water quality impact assessment will continue in the second budget period along the same lines as described in Task 4.1.2. The effort in this budget period will be to develop more detailed analysis of the most likely potential improvements or negative impacts identified in the first budget period and develop preliminary recommendations for steps that should be considered in a mature design that could maximize (for positive impacts) or minimize these impacts.

10.1.3 – Other Risks (LBNL)

This activity will continue in the second budget period during which the finalized list of additional impacts that are worth additional risk assessment and mitigation efforts will be developed.

Subtask 10.2 – Safety, Security, and Regulatory Requirements (AECOM, UCB)

All aspects of Task 4.2 EH&S activities will be progressed as part of Task 10.2. Organization-specific practices will be adapted to activities and plans appropriate for the hub. Together with input from Community partners and with results from Task 10.1, a final EH&S risk analysis will be completed. The project team will also begin development of a permitting roadmap, building upon the list generated in Task 4.2. The roadmap will help the hub team understand not only the technical permitting requirements but also the timeline of submittals, review periods, and ultimately approvals for all of the necessary regulatory documentation.

Task 11.0 – Community Partnership and Benefits (UC Berkeley, Data for Progress, Carbon180, Project 2030, LBNL, Valley Onward, Project2030, CSU Bakersfield)

We will continue working with the Community Oversight Council and other stakeholders to develop a Community Benefits Plan that reflects the community vision, goals, and objectives for a DAC hub. This will include metrics to monitor hub progress and performance, transparency, and accountability systems.

Subtask 11.1 – Community and Labor Engagement (Carbon180, Valley Onward, UC Berkeley, LBNL, Data for Progress, CSU Bakersfield)

We will continue activities started under Task 5 to support ongoing community engagement through the second phase of the project and to implement the plan to develop a Community Benefits Plan in Phase 0b. We will continue to provide education and capacity building opportunities to ensure accessibility for all interested stakeholders. We will partner with local labor organizations and leverage ongoing regional economic development efforts, including the recently-funded Community Economic Resilience Fund collaboratives in the region.

Task 11.2 – Energy and Environmental Justice and Justice40 Initiative (Carbon180, UCB, LBNL, Valley Onward, Data for Progress, Project2030)

The information from the Community Oversight Council, the community vision, goals, and criteria for a DAC hub, and the EH&S Risk analysis will inform community monitoring, data transparency, and accountability systems to ensure the hub does not result in increased environmental burden in the community. These criteria will shape the development of an assessment of community impacts of the hub. We will develop a hub design informed and guided by community-developed criteria. The ownership model, coupled with the Community Benefits Plan, will provide a pathway for implementation.

Task 11.3 – Workforce Development (UCB, Valley Onward)

In partnership with project partner, Valley Onward, the Community Oversight Council, and local labor and workforce partners, we will work with technology providers to understand workforce needs for various hub designs. We will develop a business plan for the DAC hub that includes innovative ownership models, revenue streams and sharing models, and governance structures that deliver meaningful community benefits, while identifying a risk and profit-sharing process. We will work with the technical providers to develop a hub integration plan that describes how public and private entities participate in hub design, development, and operation.

D. DELIVERABLES

"The periodic and final reports shall be submitted in accordance with the "Federal Assistance Reporting Checklist" and the instructions accompanying the checklist. In addition to the reports specified in the "Federal Assistance Reporting Checklist", the Recipient must provide the following to the NETL Project Manager (identified in Block 15 of the Assistance Agreement as the Program Manager)."

Task/Subtask Number	Deliverable Title	Due Date
1.1	Project Management Plan	Update due 30 days after award. Revisions to the PMP shall be submitted as requested by the NETL Project Manager.
4.0 and 10.0	Environmental Health and Safety (EH&S) Risk Analysis	Due 90 days prior to project completion
7.0	Phase 0a Topical Report	Due 45 day prior to Phase 0a completion
1.4	Technology Maturation Plan(s) (TMP)	Initial TMP(s) is due 45 day prior to Phase 0a completion and should be updated as needed throughout the project period of performance. Final TMP(s) should be submitted within 90 days of completion of the project.
1.5	CBP Development Proposal	Due 45 day prior to Phase 0a completion
3.8	Preliminary LCA	Due 45 day prior to Phase 0a completion. Update due 90 days prior to project completion
1.2	Business Plan	Due 90 days prior to project completion
1.3	Financial Plan	Due 90 days prior to project completion
1.5 and 11.0	CBP	Due 90 days prior to project completion
9.4	Integrated DAC System pre-FEED Study	Due 90 days prior to project completion
9.5	DAC Hub BOP Conceptual Design	Due 90 days prior to project completion

E. BRIEFINGS/TECHNICAL PRESENTATIONS

"The Recipient shall prepare detailed briefings for presentation to the NETL Project Manager at their facility located in Pittsburgh, PA, Morgantown, WV, Albany, OR, or via WebEx. The Recipient shall make a presentation to the NETL Project Manager at a project kick-off meeting held within ninety (90) days of the project start date. At a minimum, annual briefings shall also be given by the Recipient at an annual NETL review meeting to explain the plans, progress, and results of the technical effort and a final project briefing at the close of the project shall also be given."