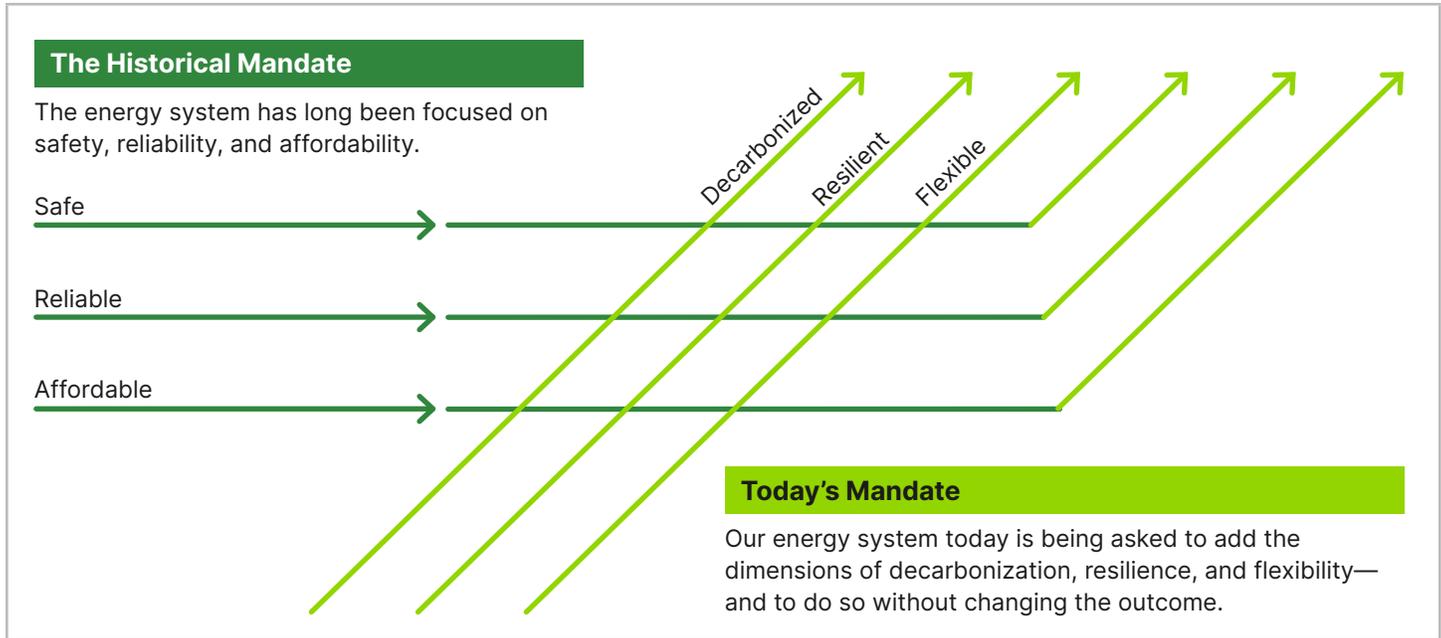


Remaking Our Energy System: Decarbonization at Scale

As a transformational tool for deep decarbonization, the decarb hub is an emerging model for remaking our energy system.



Our current energy system was built to be safe, reliable, and affordable. The energy system of the future that we're in the middle of building is also expected to be decarbonized, resilient, and flexible. Internalizing these concepts that were traditionally externalities into the system is not easy, but it is increasingly harder in the face of skyrocketing energy demand growth. Because of this, existing energy infrastructure must be repurposed and reused instead of retired.



As a transformational tool for deep decarbonization, the decarbonization hub (or, more compactly, decarb hub), is an emerging model for remaking our energy system. The birth of the decarb hub concept can't be tied to one specific point in time, but an early example is that of industrial clusters, which conceived of a scaled, source-to-demand, decarbonization solution. In 2023, the decarb hub concept was incorporated into the U.S. Bipartisan Infrastructure Law, which included financial support for regional direct air capture hubs and regional clean hydrogen hubs.

Aligning value across decarb hub stakeholders

As a full ecosystem approach to achieving a decarbonized energy system, decarb hubs include the complete value chain from energy supply to energy demand.¹ The importance of this approach lies in aligning the value propositions of a diverse set of stakeholders to gain efficiency, reduce costs, and drive greater impact.

In almost all cases, no single entity owns the complete energy value chain of a decarb hub. From government entities to private sector companies to research institutions, the specific participants in each value chain will vary depending on the type of decarbonization (e.g., carbon removal, substitute feedstocks or fuels, or process changes) and the solution to be deployed.

For example, consider that the value chain for a carbon capture and storage project may include:

- The large emitter/industrial plant to be decarbonized
- The producers of the energy and consumables to support the capture operation
- The entity that will build and manage the CO₂ transportation on infrastructure
- The sequestration site owner/operator

¹ The decarb hub model is easily extendible to decarbonization systems that are focused on the production of clean feedstocks and fuels, as well as other types of decarbonization.

There would be no point in building the rest of the carbon capture and storage value chain without a party to manage the CO₂ sequestration at the end of the chain. Developing these decarbonized value chains will require coordination across a set of distinct entities—and success will depend on aligning all value propositions into a holistic value statement for the project.

Emitters

(utilities, IPPs, large industrial)
Including thermal plant operators and carbon-intensive large industrial facilities



Capital Partners

Including commercial banks, institutional investors, infrastructure funds, among others



Demand Drivers

Companies looking to locate energy-intensive business in the southwest region, and looking for reliable low-carbon power



Academic Institutions

Universities and other academic institutions involved in evaluating carbon capture technologies and business cases in the region



Infrastructure Developers

(transport, storage) Key parties developing carbon capture infrastructure in the region



Governmental Entities

Including regulators, policy-makers, and other entities driving the development of rules and incentives for CCS in the region



Carbon Capture & Storage (CCS) Technology Providers

Parties with technology solutions that can be utilized in the development of the SWCCS Hub



Advocacy Organization

Aiming to align policy and regulatory strategies to promote market development for carbon capture projects in the region



A decarb hub framework for today and tomorrow

Existing decarb hub initiatives have gained success through alignment with specific financial, regulatory, and policy drivers. For example, industrial hubs have succeeded in Europe due to policy pressure around deep decarbonization and alignment between policymakers and financial markets on a coordinated solution for large industrial demand. In the U.S., hydrogen hubs are being formed through a U.S. Department of Energy program designed to accelerate investment in hydrogen demand and supply.²

The decarb hub model is not just fit for responding to specific policies, it can also serve as a model for value alignment among diverse stakeholders attempting to implement key components of future decarbonization system development. Addressing the full value chain helps mitigate the significant risks associated with the relatively low commercial maturity of decarbonization ecosystems.

² Energy.gov, "DOE Launches Bipartisan Infrastructure Law's \$8 Billion Program for Clean Hydrogen Hubs across U.S.," U.S. Department of Energy."

Three key components

To maximize the chance of success at scale, decarb hubs must include the following components:

1

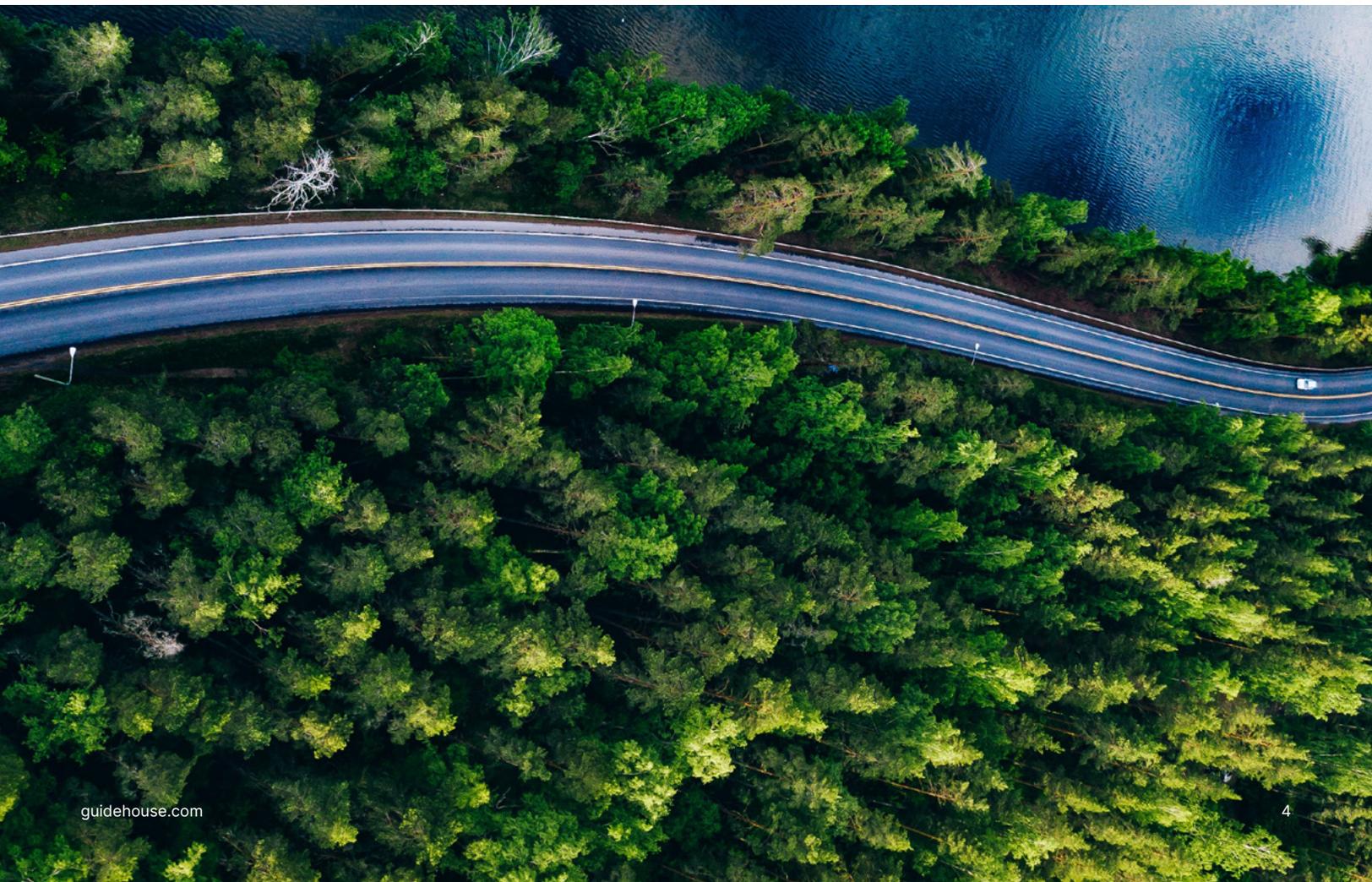
Complete value chain. The importance of encompassing the full value chain is indisputable. The hub concept is foundationally based on orchestrating an ecosystem from supply through demand. The importance of orchestration relates to the fact that the hub model is built on diverse participants who need an overarching narrative to align needs and value drivers.

2

Orchestrator. Like a general contractor, the orchestrator facilitates alignment across the value chain. The distinction is that there may be no single customer for whose benefit the project is conducted. An orchestrator could be an entity within or outside the value chain, representing users as a whole or an intersection of drivers that serve as the ecosystem's foundation. In almost all cases, the orchestrator functions like a project management office to ensure that business, financial planning, permitting, regulatory, safety, community coordination, and other considerations are properly planned and executed, and stakeholder needs are considered and addressed.

3

Financial enablers and penalties. Decarb hubs can be part of a governmental or other development program or motivated and driven by grassroots needs. In both cases, having financial enablers or penalties is critical because they incentivize doing something different instead of "business as usual." Financial enablers may include tax credits, direct federal grant funding, or contracts for different models. Penalties may include carbon taxes or specific consequences for missing emissions reduction targets.

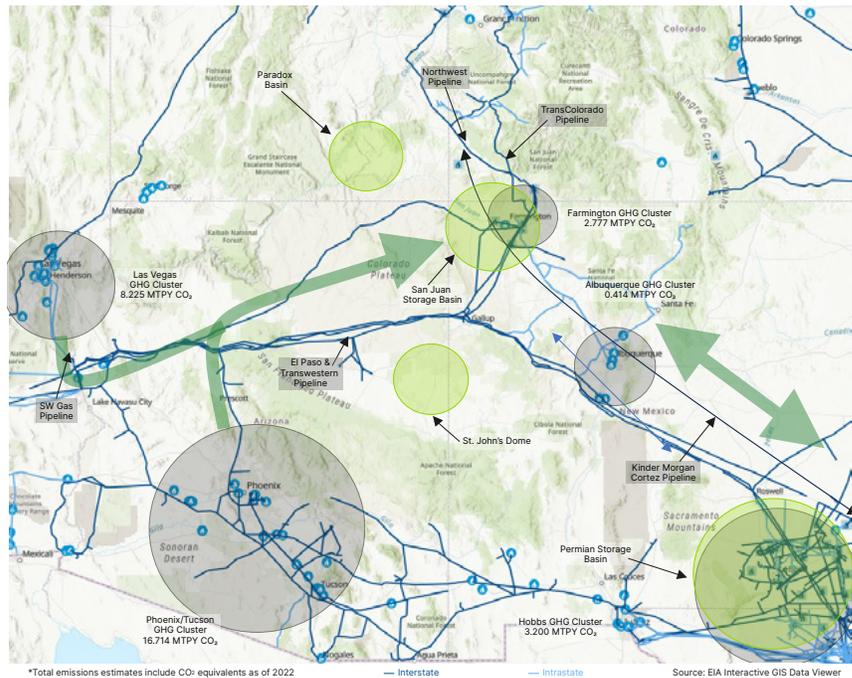


CASE STUDY

Southwest Carbon Capture Hub

The desert southwest U.S. is facing unprecedented electric demand growth. A review of regional utility resource planning filings forecasts that by 2045, electricity demand is expected to double. This projected energy demand growth means that existing thermal plants in the region will likely need to continue operating into the future—and more thermal generation will be needed to complement a massive buildout of solar, wind, and storage resources. Continued use of natural gas plants combined with potential additions to the thermal generation portfolio challenge this region's decarbonization goals.

To address these concerns, our team has begun orchestrating the development of an at-scale multi-state carbon capture hub. We envision an entire ecosystem that has the potential to reduce emissions in the region by 20-40 MTCO₂e per year. For any individual party in this ecosystem, the notion of investing in a carbon capture and storage system is challenging because the cost is too high on an individual project basis.



With federal support and changing requirements to manage carbon within an energy system, it's now more feasible for the desert southwest to collectively focus on building at-scale decarb hub models that can provide the Southwest with a scalable framework, cost savings, increased investment, and a faster project timeline.

Five steps to building a decarb hub

To build a successful decarb hub, you'll need to:

- 1. Identify the drivers.** To be effective, decarb hubs need to be intrinsically connected to stakeholder needs. In many cases, the appropriate set of stakeholders is determined by the region in which the hub is located. Often it will connect to more than one motivating factor or solve more than one problem.
- 2. Map the complete value chain.** Once you've clearly defined the problem, you need to map the complete value chain. For example, if you're planning to produce e-chemicals, try drawing a diagram that includes your production process, supply chain, end users, and all the connective infrastructure pieces such as storage, trucks, pipelines, and specialized end-use equipment. To be successful, the complete value chain needs to be present, whether it can be leveraged from existing components or will need to be built by the hub itself.
- 3. Identify the orchestrator.** Whoever plays this critical role must carry forward the vision and ensure that hub participants stay connected and engaged. To accelerate ecosystem development, the orchestrator also needs to intimately understand regional energy system drivers of change and viable funding pathways. Whether an internal hub participant or external party, the orchestrator must be an effective communicator who's embedded in the region and highly familiar with its landscape and challenges.

The potential of decarb hubs to create sustainable economic models cannot be overstated.

- 4. Engage stakeholders.** Early-stage stakeholder engagement is key and requires validating each stakeholder’s value proposition to ensure alignment with the overall vision. Securing effective stakeholder engagement early on also helps build strong partnerships that foster enduring collaboration among diverse groups.
- 5. Develop a viable business model.** A successful decarb hub will develop new revenue streams and long-term financial stability for the parties involved. Early-stage evaluation of potential business models—including consideration of potential incentives and funding sources—is needed to determine if sufficient value can be produced for everyone while ensuring economic vitality and environmental sustainability.

Creating lasting pathways for commercial viability

Decarb hubs offer a new model for decarbonizing heavy industrial emitters and energy systems. While they may not work in every situation, they can provide the ideal solution for communities facing a complex set of drivers, “first-mover” risks, or complete value chain development needs.

By acting as centralized networks and launch points for mature, regionwide decarbonization, they can help foster innovation, create lasting pathways for commercially viable decarbonization solutions, and develop new economic opportunities through transformed infrastructure and clean energy generation.

Ultimately, the transition to a low-carbon energy supply chain hinges on our collective ability to mobilize and coordinate efforts across multiple sectors and regions.

The potential of decarb hubs to create sustainable economic models cannot be overstated. Without them, deep decarbonization efforts that will disrupt the current fabric of our energy system will have very little likelihood of success.

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