

Streamlining your CCUS Permit Application Using Generative AI

A Multi-Agent Collaboration Approach

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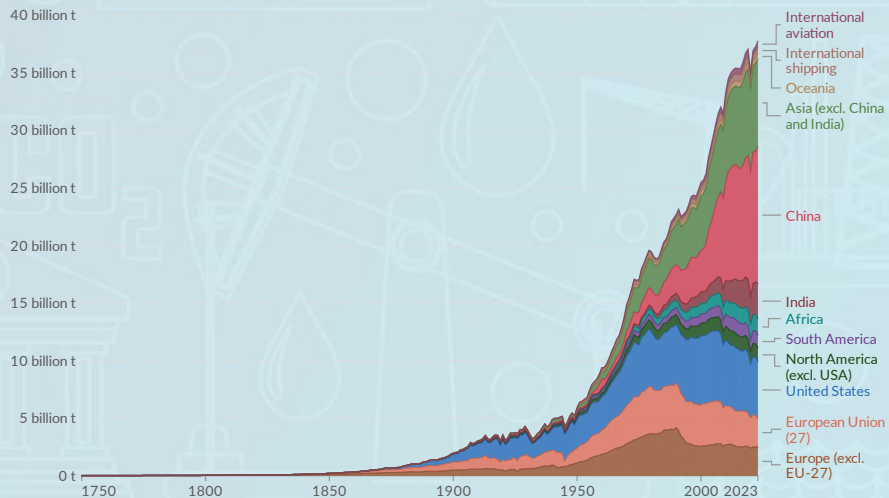
Amazon Web Services

Why CCUS Matters

- CCUS is **critical** for achieving net-zero emissions.
- Rising global demand for safe, permanent **CO₂ storage**.
- **Class VI wells** provide a regulatory framework to protect underground sources of drinking water.

Annual CO₂ emissions by world region

Emissions from fossil fuels and industry¹ are included, but not land-use change emissions. International aviation and shipping are included as separate entities, as they are not included in any country's emissions.

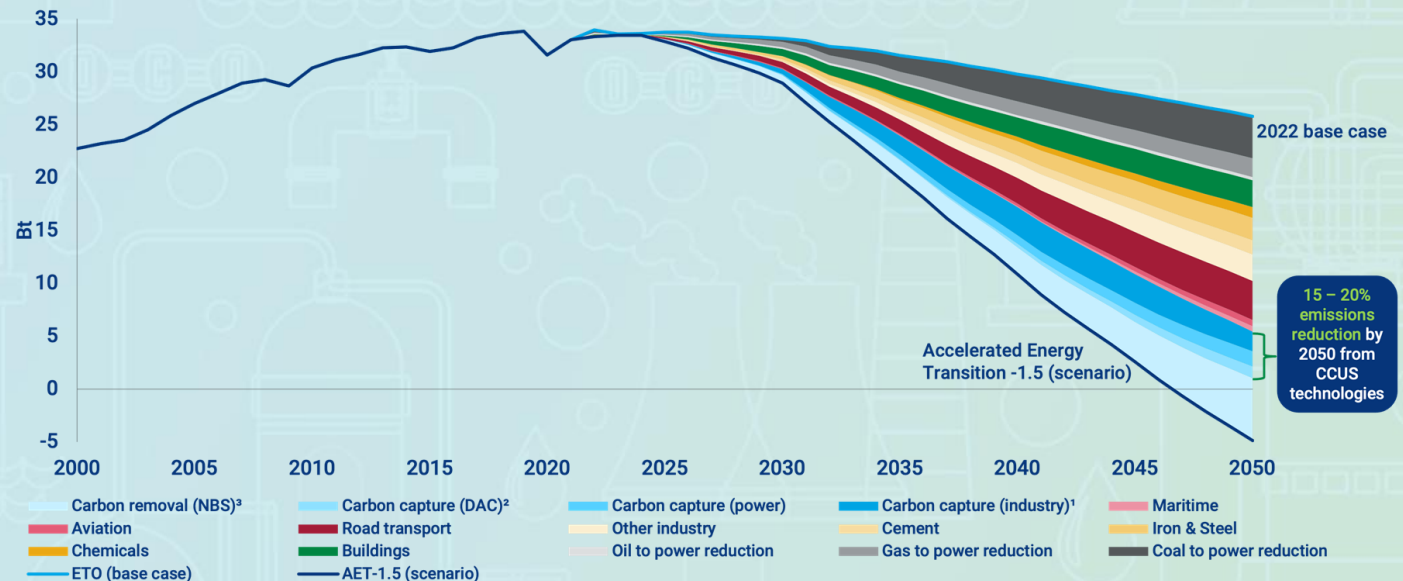


Data source: Global Carbon Budget (2024)

OurWorldinData.org/co2-and-greenhouse-gas-emissions | CC BY

1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO₂) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO₂ includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

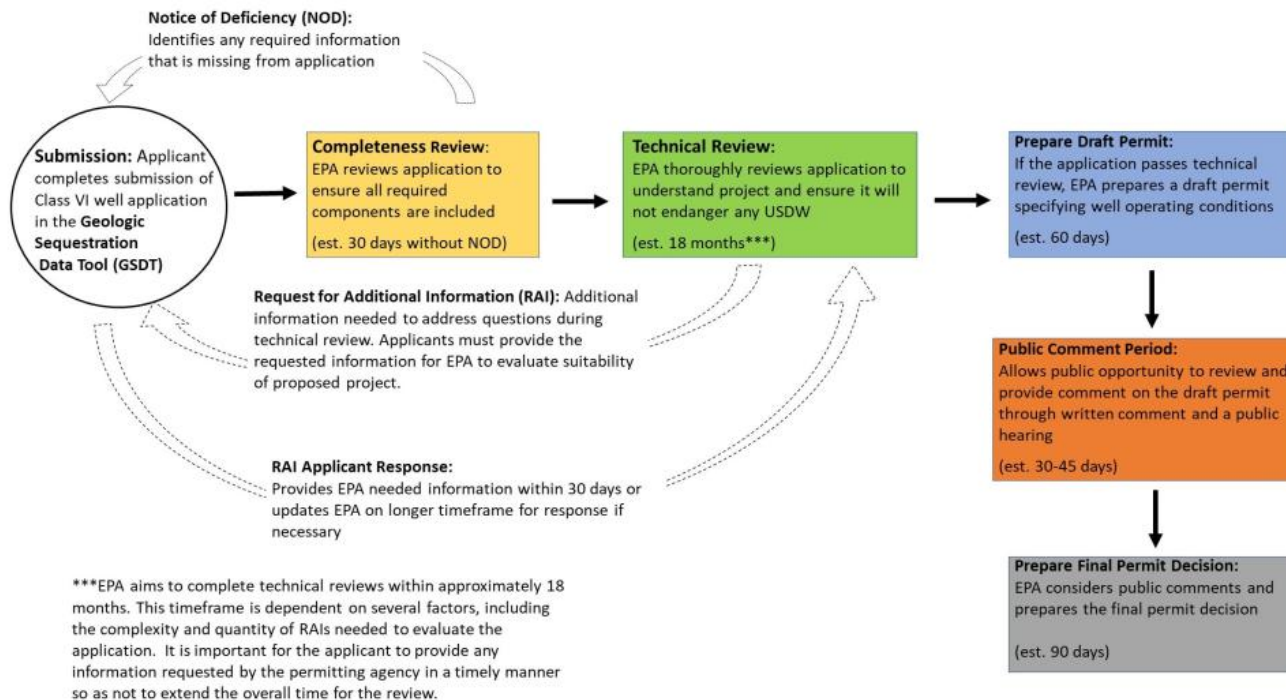
CCUS would account for 15-20% of global CO₂ emissions reductions under our AET-1.5 scenario



Source: Wood Mackenzie Energy Transition Service. 1) Includes CCS for blue hydrogen; 2) Direct air capture; 3) Nature-based solutions

Challenges in Class VI Permitting

Class VI permitting process

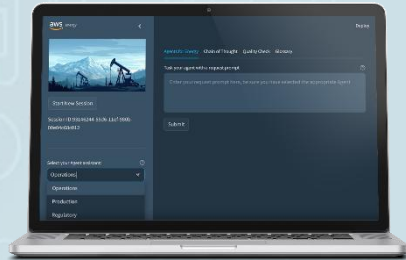


- **Complex Regulatory Requirements** (e.g., 40 CFR Part 146 Subpart H).
- **Technical Depth:** Reservoir characterization, injection modeling, and risk assessment.
- **Fragmented Information:** Multiple data sources and stakeholders

Agentic AI Concept

- **AI-Driven Collaboration** among specialized sub-agents.
- **Supervisor Agent** orchestrates tasks.
- **Streamlined Access** to authoritative knowledge bases.
 - AI Assistants enable line-of business personas speed up time-consuming energy workflow steps
 - *Geologist quickly characterizing reservoirs using Industry databases, commercial data subscriptions, and internal corporate files*

Business Architecture



PRE-BUILT AGENTS EXAMPLES

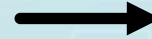
Maintenance

Production

Regulatory

Drilling







Reservoir



SAMPLE DATA

Drilling & Completions 	 Regulatory
Wells 	 OSHA
HSE 	 Production

YOUR DATA & TOOLS

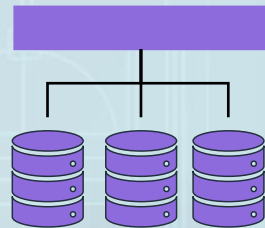
Land 	 Estimator
CMMS 	 Risk Calculator
HSE 	 ...

How does Agentic AI help line-of-business workers?



Reduce Deployment Complexity

Realize business value from use case focused persona-driven GenAI in less time



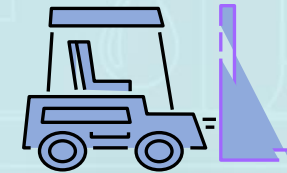
Data Accessibility

Democratize crucial corporate and commercial data



Built-In Energy Expertise

Organization and configuration aligned to energy & utilities scenarios and data sets



Autonomous Actions

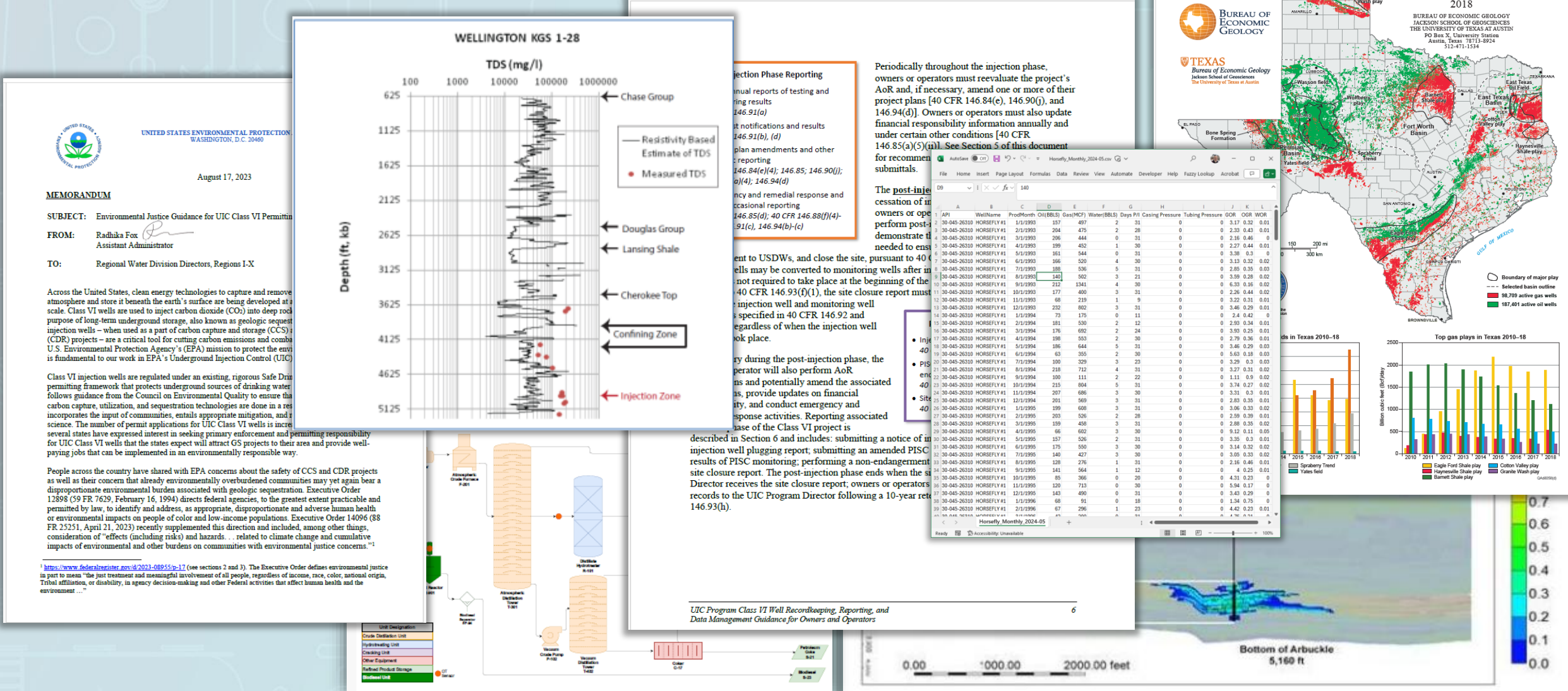
Agents can perform tasks, not just assist employees but act as one



Open-Source

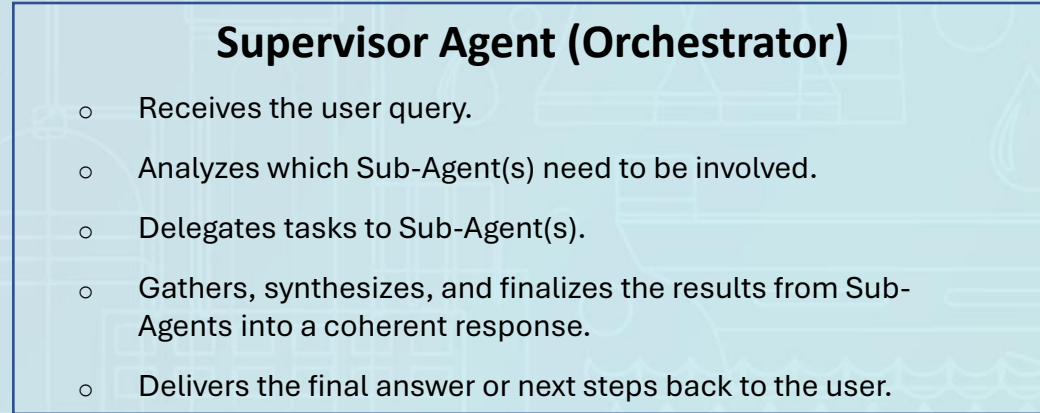
Customer-driven priorities and development roadmap

Industry Sample Data for CCUS Projects

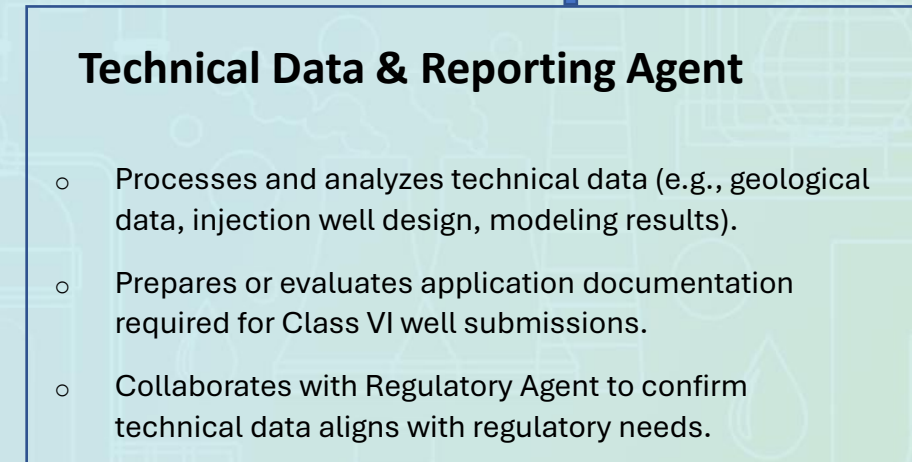


Agentic Workflow

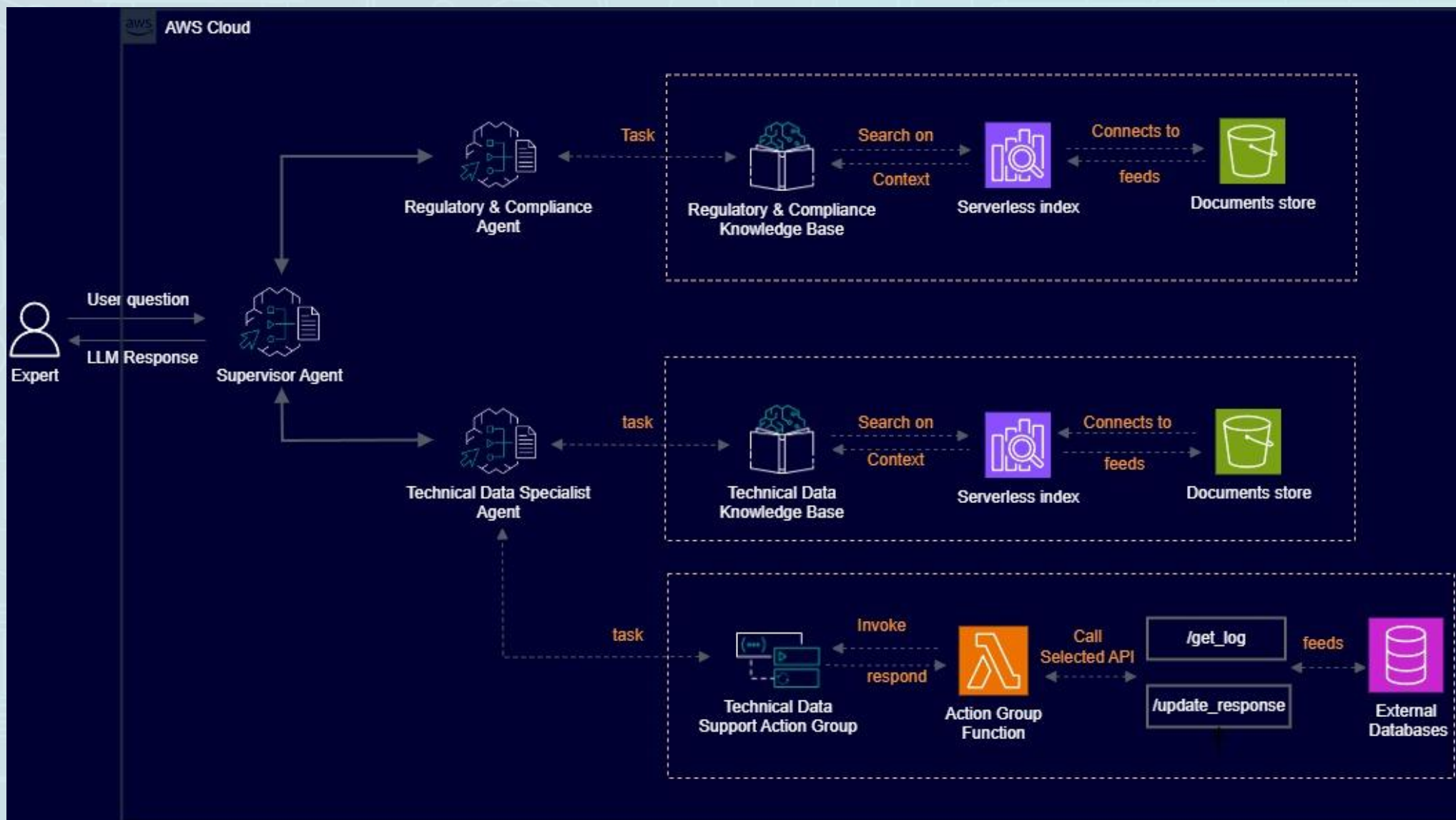
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CCUS Multi-Agent Workflow



Demo

What specific Class VI construction standards and casing requirements do I need to address in my permit application for a new injection well?

< Hide trace

Enter your message here

:

Run

Multi-agent collaboration trace timeline

For agents with Multi-agent collaboration enabled, each subsequently invoked Agent collaborator is displayed. Each bar within the trace timeline can be clicked to show the specific breakdown for that Agent collaborator.

(1)supervisor

Time (seconds)0.00s

Trace

Session summaries

Trace (1)

Request ID d9797c27-b7a4-43c0-94fe-e0a6197058f8

< ing Trace

Routing Trace

Orchestration and Knowledge Base

Post-Processing Trace

>

Orchestration and Knowledge Base

After running a prompt in the test window, this orchestration trace allows you to explore the trace steps to understand the linear chain of thought used by the agent's orchestration prompt component. If a knowledge base was invoked, the trace also allows you to see how the results from the knowledge base were summarized to generate an observation that is used for for orchestrating the next step or generating the response.

► Trace step 1

Show config

Case 1



What specific Class VI construction standards and casing requirements do I need to address in my permit application for a new injection well?



The specific Class VI construction standards and casing requirements for your permit application for a new injection well include:

Regulatory Requirements:

1. The well must be constructed to prevent fluid movement between Underground Sources of Drinking Water (USDWs) or unauthorized zones.
2. The design must allow for appropriate testing devices and workover tools.
3. The well must permit continuous monitoring of the annulus space between injection tubing and long string casing.
4. The casing and cement must have sufficient structural strength for the life of the project.
5. All materials must be compatible with expected fluids and meet or exceed standards from American Petroleum Institute, ASTM International, or comparable standards approved by the Director.

Technical Requirements:

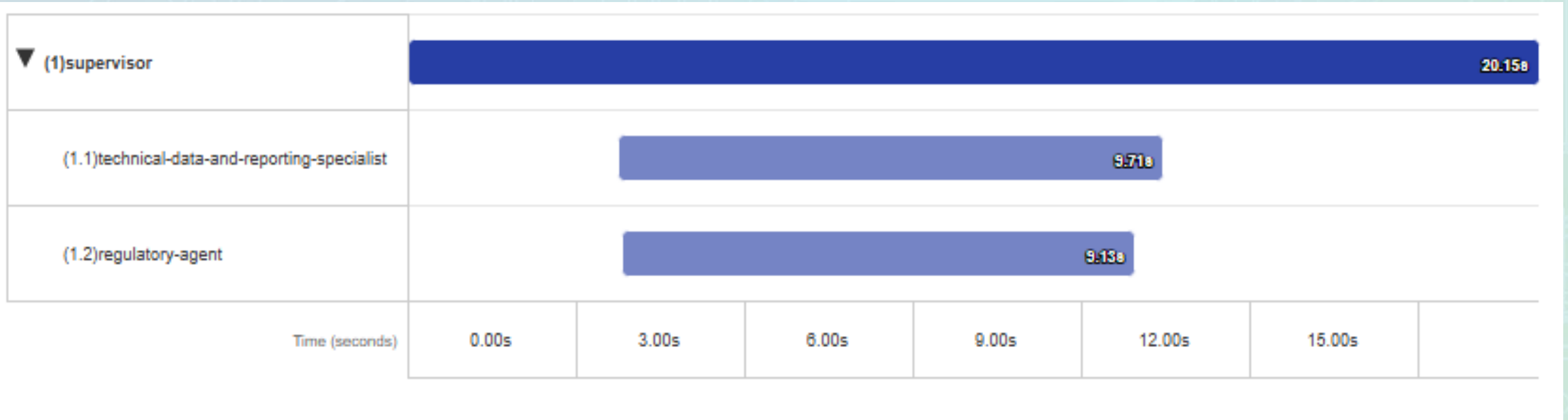
1. The well must be constructed with materials and cements that can withstand exposure to carbon dioxide and CO₂/water mixtures throughout the project's lifetime.
2. The wells must be cased and cemented to prevent fluid movement between USDWs.
3. They must be equipped with an automatic surface shut-off system that activates if operating parameters deviate from permit limitations.
4. The well must allow for continuous monitoring of the annulus space between injection tubing and long string casing.
5. Must permit the use of appropriate testing devices and workover tools.
6. The casing and cement must have sufficient structural strength for the project's lifetime.
7. Injection must occur through tubing with a packer set at a depth opposite a cemented interval.

Operators must submit specific technical information including:

- Depth of setting
- Carbon dioxide stream characteristics (chemical content, corrosiveness, temperature, density)
- Maximum proposed injection and annular pressure
- Injection rate specifications
- Tubing and casing sizes
- Tubing tensile, burst, and collapse strengths

Please ensure that your permit application includes these requirements to meet Class VI regulations.

Multi-agent collaboration trace timeline



Agent Interaction breakdown

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....
},
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.....
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Case 2



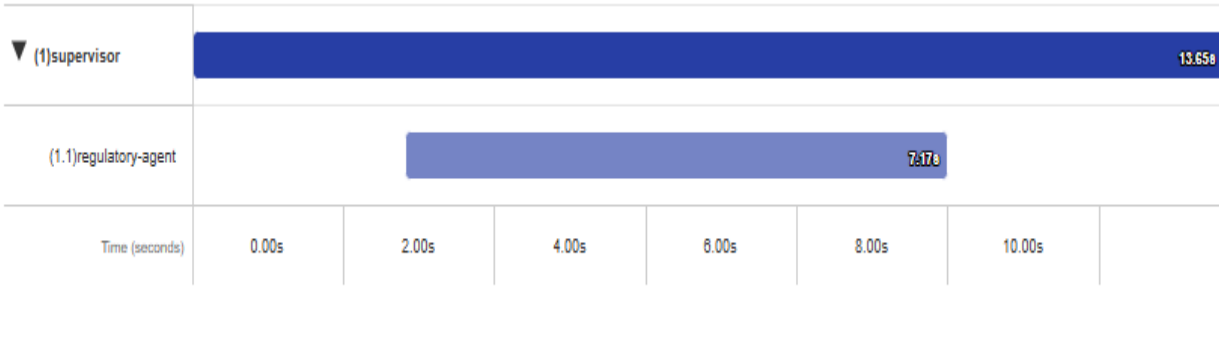
What are the public notification and stakeholder engagement requirements before submitting a Class VI permit application?"



The public notification and stakeholder engagement requirements before submitting a Class VI permit application include:

- Beginning stakeholder outreach as early as possible in the permitting process, even before issuing a draft permit.
- Providing notice through various means such as newspaper advertisements, radio, mailings, or emails to interested parties.
- Sending specific notifications to state and local oil and gas regulatory agencies, state agencies regulating mineral exploration and recovery, the Director of the Public Water System Supervision program, and all agencies with jurisdiction over wells in the state.
- Utilizing the Internet and social media to explain potential GS projects, describe technologies, and post information about project developments, including schedules for hearings and opportunities for involvement.

This approach ensures accessibility and transparency to a wide audience.



```

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Key Takeaways

- **Agentic AI** brings clarity and efficiency to Class VI permitting.
- **Modular Workflow** ensures specialized expertise in both regulatory and technical spheres.
- **Comprehensive Knowledge Bases** keep guidance accurate and updated.

Future Vision

- **Additional Sub-Agents:** Financial Modeling, Community Outreach, Liability Management, Timeline specialist.
- **Multi-Lingual Support** for international CCUS projects.
- **Continuous Learning:** ML enhancements from new industry datasets and completed permit applications.