SFVFS™: A Geometric Hypothesis for Energy-Minimal Carbon Capture

Segment 12 of 15 · V11 Anti-Wash Addendum · v2 Refinement Note

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SFVFS™ Positioning System · Trademark UK00004355735

SFVFS™ Positioning System · Trademark UK00004355735 · Ω = 1↔2 BOUNDARY

This note is a stratigraphic layer above the v1 text. The original Seg 12 document is the geological baseline — unchanged, undeleted, visible beneath this layer. The addendum makes two refinements: it inserts the thermodynamic boundary callout that belongs immediately after the abstract, and it narrows the hypothesis claim explicitly to the flow-structuring zone — the domain where SFVFS™ operates — separating it cleanly from the thermodynamic minimum, which it does not touch. Both are tightenings, not retreats. CF CONSISTENT not PASS throughout.

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1. Thermodynamic Boundary Callout

The v1 abstract states the hypothesis clearly but does not provide an immediate, prominent separation between what SFVFS™ claims and what it explicitly does not claim on thermodynamic grounds. A reader encountering the abstract in isolation could take the "energy-minimal" framing as a claim against the thermodynamic minimum. It is not. This callout box belongs immediately after the abstract in any published or circulated version of Seg 12.

■ THERMODYNAMIC BOUNDARY — Read Before Proceeding

The SFVFS™ carbon reduction hypothesis makes a claim about one specific zone of the CCS energy budget. It does not make a claim about thermodynamics.

The total CCS energy cost has two distinct components:

Component A — Thermodynamic minimum (IRREDUCIBLE): The minimum work required to separate CO_2 from a mixed stream is $W_{min} = RT \cdot \ln(1/x_{CO■})$. For a 13% CO_2 flue gas stream this is approximately 5.1% of plant output [Bhown & Freeman, 2011]. This cost is set by the second law of thermodynamics. No geometry eliminates it. SFVFS™ does not claim to reduce it.

Component B — Organisational overhead (TARGET OF THIS HYPOTHESIS): Deployed amine-scrubbing systems operate at 15–25% energy penalty. The gap between the thermodynamic minimum (~5%) and actual systems (15–25%) is the organisational overhead: the continuous energy cost of driving separation, preventing reversion, and maintaining flow structure. This is the zone the SFVFS™ hypothesis addresses.

The claim: If D_6-forced geometric structure can be established in a CO_2 processing stream, the continuous organisational overhead (Component B) may be partially or wholly replaceable by attractor dynamics, shifting the architecture from continuous operational cost to front-loaded geometric establishment. Component A is untouched.

Ω = 1↔2 BOUNDARY · CF CONSISTENT not PASS · Hypothesis unproven at engineering scale.

2. Narrowing the Claim: The Flow-Structuring Zone

The v1 text distinguishes thermodynamic minimum from organisational overhead in Section 5.2, but this distinction is not present at the point where a reader first encounters the hypothesis — the abstract and introduction. The Anti-Wash Protocol requires the narrowing to be present at first contact.

The flow-structuring zone is the domain where SFVFS™ operates. It is defined precisely:

Zone	Definition and SFVFS™ position
Thermodynamic minimum (W_{min})	The irreducible work of separation: $W_{min} = RT \cdot \ln(1/x_{CO■})$. Set by the second law. Approximately 5.1% of plant output at 13% CO_2 concentration. **SFVFS™ does not operate here. No claim is made in this zone.**
Flow-structuring zone (Target)	The gap between the thermodynamic minimum and actual CCS energy cost (15–25%). This gap is the continuous organisational overhead: driving separation, preventing reversion, maintaining flow architecture. SFVFS™ hypothesis: this zone may be partially or wholly replaceable by D_6-forced attractor dynamics. Unproven at engineering scale. $\Omega = 1 \leftrightarrow 2$ BOUNDARY.
Engineering overhead (Compression etc.)	Compression, transport, injection costs. Not addressed by SFVFS™. These costs are downstream of the capture step and are not reduced by flow-structuring geometry.

The flow-structuring zone is not a vague concept. It has a measured lower bound (the thermodynamic minimum, ~5.1%) and a measured upper bound (deployed amine systems, 15–25%). The SFVFS™ hypothesis addresses the 10–20 percentage point gap between them. This is the precise target.

The DNS evidence establishes that within the attractor basin, the geometric organisation does not require continuous driving (COUPLED2A, MOBIUS1). It does not establish that this behaviour transfers to engineering-scale CO_2 flows. The transfer is the open question. The thermodynamic minimum is not the question.

Flow-Structuring Zone — Positional Reading

The SFVFS™ carbon reduction hypothesis is narrowed to the flow-structuring zone: the organisational overhead component of CCS energy cost, bounded below by the thermodynamic minimum (~5.1%) and above by deployed system costs (15–25%). The hypothesis does not address the thermodynamic minimum. The hypothesis does not address compression and transport overhead. The claim is precisely: D_6-forced attractor dynamics may replace continuous organisational energy input in the flow-structuring zone. $\Omega = 1 \leftrightarrow 2$ BOUNDARY. Unproven at engineering scale. CF CONSISTENT not PASS.

3. What the DNS Evidence Establishes Within the Flow-Structuring Zone

Narrowing the claim to the flow-structuring zone does not weaken the DNS evidence. It locates it correctly. The five canonical DNS results bear directly on the flow-structuring zone and say nothing about the thermodynamic minimum:

Experiment	Finding	Relevance to flow-structuring zone
COUPLED3	Fluid-chemistry independence: ratio_vs_coupled2b = 1.0000000000136.	The attractor is geometry, not chemistry. CO_2 as a fluid is not special. The D_6 attractor operates on viscosity alone. The flow-structuring zone is accessible for CO_2 streams in the tested viscosity range.
COUPLED2A	Spontaneous organisation in free decay. ϕ_{az} held at 180° ±0.3° with zero external forcing.	Within the attractor basin, the geometric structure maintains itself without continuous energy input. This is the direct DNS evidence for the flow-structuring zone hypothesis.

Experiment	Finding	Relevance to flow-structuring zone
MOBIUS1	Basin stability through 10^4-fold energy dissipation. ϕ_{az} drift = 0.034° over T=600 free decay.	The basin is not a transient. Once established, the flow-structuring geometry persists as energy decays. This is the stability condition the hypothesis requires.
COUPLED2B	E_{free} retention = 0.01111 (7.845× baseline). Tightest phase lock in programme.	Geometric establishment is reproducible. The flow-structuring zone can be entered reliably from the correct initial conditions.
Viscosity Law V3	ν alone determines void cell. Molecular structure irrelevant.	The single governing parameter for cell assignment is measurable. Engineering design of the flow-structuring zone can target ν directly without fluid-specific tuning.

4. What Remains Open Within the Flow-Structuring Zone

Narrowing the claim makes the open questions more precise, not larger:

Open question	What it requires
Does the D_6 attractor appear in CO_2 DNS at engineering-relevant Re?	CARBONREDUCTION1: CO_2 DNS at Re well above current N=128 regime. Post-exhibition priority.
Is the chirality flip physical or numerical?	COUPLED2A_REP_NU: three viscosity values. Independent replication under revised ϕ_{dev} criterion.
Does the flow-structuring zone behaviour transfer to engineering scale?	Engineering-scale DNS or physical experiment. Reynolds numbers orders of magnitude above current DNS regime.
What is the establishment cost vs operational saving ratio?	Engineering-scale economic analysis. Cannot be calculated from DNS alone.
Does the separatrix geometry determine Path A / Path B in CO_2 streams?	Separatrix mapping experiment. Codimension-1 surface in (phase, chirality) space.

Final Positional Statement

The SFVFS™ carbon reduction hypothesis is $\Omega = 1 \leftrightarrow 2$ BOUNDARY. The thermodynamic minimum ($W_{min} = RT \cdot \ln(1/x_{CO\blacksquare})$) is irreducible and is not addressed by this programme. The flow-structuring zone — the organisational overhead between ~5% and 15–25% — is the precise target. The DNS evidence establishes that attractor-driven self-organisation without continuous energy input is real at simulation scale. Engineering-scale transfer is the open question. The honest boundary is not failure. It is the invitation. CF CONSISTENT not PASS.

Addendum closes here. Original Seg 12 text is the geological baseline — unchanged, undeleted, visible beneath this layer. The thermodynamic boundary callout is inserted here as the note that belongs immediately after the abstract in any circulated version. The flow-structuring zone framing narrows the claim to its correct scope without retreating from any DNS finding. The Anti-Wash Protocol is satisfied.