Scout Harvester Gen-Set Thesis

Shilofarm LLC | As of May 2026

Engineering Analysis — Stage 1 Supporting Document

Scope: This document records the analytical basis for evaluating the Scout Harvester EREV gen-set architecture as it supports the Terra farm truck candidacy. It is derived from first-principles back-of-envelope analysis, patent evidence, Scout Motors direct correspondence, and confirmed VW Group sourcing data. It is not a commit document. The evaluation gate remains 2028-2029.

1. Architecture — Series EREV, Not Hybrid

The Scout Harvester is a pure series EREV. The internal combustion engine never drives the wheels. Its sole function is to turn a generator, which feeds the DC bus. The control system allocates DC bus power in real time between traction motors and battery charging. This is architecturally distinct from parallel hybrids (Toyota, Honda) and series-parallel hybrids (Chevrolet Volt) where the ICE contributes mechanically to propulsion at some operating conditions.

The series architecture simplifies the control problem: the gen-set runs at one optimized point or not at all. There is no torque blending, no mechanical coupling path to manage, no ICE load-following the drivetrain. The Volt could not recharge the battery meaningfully while driving because the ICE was doing two jobs. The Harvester gen-set has one job.

2. Engine — EA211 1.5L, Silao Mexico, Naturally Aspirated

VW Group CFO Arno Antlitz confirmed on the Q1 2025 earnings call that the Harvester gen-set engine will be sourced from the VW Group plant in Silao, Guanajuato, Mexico. The Silao facility produces EA211 (1.5L) and EA888 (2.0L) four-cylinder engines, with capacity exceeding 430,000 units annually. The plant has been operational since January 2013.

Antlitz confirmed the engine will be naturally aspirated, non-turbocharged. Scout CEO Scott Keogh described it as a 'good, high-output, four-cylinder, small engine.' A patent filing for the rear-mounted gen-set assembly shows a four-cylinder unit tilted at 50 degrees for packaging clearance, mounted in a dedicated subframe behind the rear axle. VW Group's four-cylinder inventory depth means the gen-set engine selection draws from a thoroughly proven parts base — Scout is integrating, not inventing.

Parameter	Value	Basis
Engine family	EA211 (probable) or EA888	Silao plant confirmed; displacement TBD by Scout
Displacement	1.5L (EA211) or 2.0L (EA888)	Both produced at Silao; EA211 consistent with 'small

		engine' characterization
Turbo	None — naturally aspirated	VW CFO confirmed
Mounting	Rear of frame, behind rear axle, 50 degree tilt	Patent filing
Sourcing	VW Group Silao plant, operational since 2013	VW CFO Q1 2025 earnings call
Annual volume	430,000+ engines at Silao	VW de Mexico production data 2023

3. Power Envelope — Back of Envelope

3a. Consumption Rate

NMC pack: 125 kWh midpoint (Scout support: 120-130 kWh). NMC target range: 350 miles. Consumption rate: 125 / 350 = 0.357 kWh/mile. This is consistent with full-size BOF truck benchmarks: F-150 Lightning ~0.44, Rivian R1T ~0.38. Scout's slightly lower figure is plausible given EREV architecture allows drivetrain optimization.

3b. LFP Battery Range Before Gen-Set

LFP pack: 65 kWh midpoint (Scout support: 60-70 kWh). At 0.357 kWh/mile: 65 / 0.357 = approximately 182 miles on battery alone. LFP chemistry supports full 0-100% depth of discharge without meaningful cycle degradation — 2,000-3,000+ full cycles versus NMC's 1,000-1,200 at full depth.

3c. Gen-Set Contribution for 500-Mile Target

Gap: 500 - 182 = 318 miles requiring gen-set contribution. Energy required: 318 x 0.357 = 113 kWh delivered electrically to the bus.

3d. Fuel Required

Thermal Efficiency Assumption	Fuel Energy Required	Gallons Required
30% (book value, conservative)	377 kWh	~11.4 gallons
36% (single-point optimized NA)	314 kWh	~9.5 gallons
38-40% (best-case fixed-point tune)	281-297 kWh	~8.5-9.0 gallons

Working estimate: 10-12 gallon fuel tank covers the 500-mile target with reserve at realistic thermal efficiency. This is a small tank — substantially smaller than a conventional truck tank — consistent with rear-of-frame packaging alongside the gen-set. The fixed-RPM breathing optimization likely recovers 2-3 gallons off the naive book-value estimate.

4. Engine Sizing and Power Architecture

4a. Sustained Cruise Requirement

500 miles at highway speed: approximately 8 hours. Gen-set active for approximately 5 hours (318 miles). Required electrical output: 113 kWh / 5 hours = approximately 22-23 kW continuous. At 30% thermal efficiency, shaft power required: approximately 40-45 HP continuous at steady highway cruise on flat ground.

4b. Single-Point Optimization Advantage

A propulsion engine must produce acceptable torque and power across a broad RPM band — the design constraint that forces compromises in breathing, timing, and combustion chamber geometry. A generator-duty engine has one design target: find the RPM point that maximizes thermal efficiency and hold it there. This frees the engineer to optimize intake runner length and diameter, exhaust tuning, ignition timing, and fuel injection calibration for a single operating point — the most favorable design space an ICE engineer works in.

Naturally aspirated HP/liter at a single optimized point: 65-80 HP/liter is achievable versus 60-70 HP/liter for broad-band propulsion tune. A 1.5L EA211 in single-point generator tune is credibly rated at 90-100 HP at its efficiency peak — not by pushing the engine hard, but by removing every propulsion-duty compromise. The engine person working this problem is liberated, not constrained.

4c. Dual-Role Power Architecture — Gen-Set and Battery

The gen-set and battery serve explicitly separated roles in the series EREV architecture. Conflating them produces incorrect conclusions about capability.

Gen-set role: sustained energy source. Runs at fixed RPM, fixed load, fixed efficient point. Output is steady and bounded — approximately 90-100 HP equivalent electrical. It cannot supply instantaneous high power demand.

Battery role: high-power burst source. Traction motors drawing from the 65 kWh LFP pack can deliver 400+ HP instantaneously regardless of altitude, temperature, or grade. There is no intake air density problem, no combustion efficiency loss at elevation, no torque curve to manage. The power is flat and immediate from zero RPM.

Together they cover what neither can do alone. The gen-set handles base cruise load continuously at its efficient point. The battery handles everything interesting — passing, grade peaks, acceleration transients. A 2-second passing demand spike of 250-300 HP draws approximately 1-1.5 kWh from the battery — trivial against a 65 kWh pack. The gen-set continues its steady contribution throughout and does not notice the event.

Operating Condition	Traction Demand	Gen-Set Output	Battery Role

Highway cruise, flat	~40-45 HP equivalent	~90-100 HP equivalent	Charging from surplus
Grade climb, unloaded	~70-80 HP equivalent	~90-100 HP equivalent	Minor draw, recovering on descent
Grade climb, loaded trailer	~150-200 HP equivalent	~90-100 HP equivalent	Active draw — burst source
Passing on grade	~250-300 HP momentary	~90-100 HP equivalent	Primary source for burst
Descent with regen	Negative (regen adds)	~90-100 HP equivalent	Absorbing regen plus gen-set
Light city / farm	~15-20 HP equivalent	Off (battery only)	Primary source

Note on altitude: a naturally aspirated V8 loses roughly 1% of rated output per 300 feet of elevation. At Stevens Pass (4,061 feet) or Blewett Pass (4,102 feet) a conventional truck engine is running at approximately 87% of rated output — exactly when full power is needed most. The Terra's traction motors lose nothing to altitude. The gen-set is naturally aspirated but is already running at 50-60% of rated output at its fixed efficient point — altitude degradation does not threaten its contribution margin.

5. Hysteresis Control, SOC Management, and Charge Strategy

5a. Basic Hysteresis Operation

The gen-set does not run continuously. It operates within a battery state-of-charge hysteresis band: start at the lower threshold, run to the upper threshold, shut down. Every run cycle is at the optimized RPM point — no throttling, no partial-load inefficiency. This is a simple, clean control loop.

For trips under 182 miles the gen-set does not start at all. LFP chemistry's tolerance for full depth discharge means the entire 65 kWh is available without cycle-life penalty every day. For trips in the 182-350 mile range the gen-set runs intermittently, topping the battery within the control band as needed.

5b. User-Commanded SOC Hold Mode

The Chevrolet Volt established the operational precedent: a user-selectable Hold mode that commands the ICE to maintain battery SOC at the current level rather than allowing depletion. The use case is exact — preserve battery reserve for a known high-demand segment ahead, then use it when needed.

The pure series EREV architecture supports this cleanly. The hysteresis control loop already manages SOC to a target band. A user-commanded hold at 80% SOC is a parameter change in that control loop, not a new architecture. Rivian's software stack has the sophistication to implement this — it is a mode, not a redesign.

Operational application for the high-demand mission: command gen-set to maintain 80% SOC from trip departure. Gen-set runs early on flat ground where it can keep up easily. Battery arrives at the mountain segment at 80% — 52 kWh of burst reserve available. The climb draws from that reserve while the gen-set continues its steady contribution. Descent regen recovers into a partially depleted pack, maximizing regen capture because there is room to absorb it.

5c. Charging Stop Strategy

It is not good practice to use the gen-set to arrive at the next charging stop with the battery full. The charger is a source of grid-supplied electrons at higher efficiency than the gen-set thermal conversion chain. Running the gen-set to top the battery before a charging stop wastes fuel and adds unnecessary gen-set cycles.

The correct arrival target is 20-25% SOC — let the grid fill it. A navigation-aware energy management system should suppress gen-set activation in the final segment before a known charger, arrive low, charge on grid, and depart full. Rivian's software stack implements trip-aware energy management on the R1 platform; the same logic applies to Scout.

For farm use: depart full on battery, use battery first for daily operations, engage gen-set only for trips exceeding battery range, charge overnight on off-peak grid power. The gen-set is the exception, not the default operating mode.

6. High-Demand Mission Analysis — Chelan Class Run

6a. Mission Profile

The Chelan class run is a V=4 mission: 200+ mile round trip, significant mountain grade (Stevens Pass at 4,061 feet or Blewett Pass at 4,102 feet), heavy implement on return (rollover plow, swather, or equivalent), occurring once or twice annually. This mission cannot be dismissed as out-of-envelope — it is a core farm truck requirement.

The reference mission: Thurston County to Chelan, WA, returning with a large rollover plow on a car trailer. Larry (2006 F-150 5.4L V8) executed this mission with a mid-trip fuel stop, fuel economy degrading from ~17 MPG highway to ~10 MPG under load on grade. Larry's ceiling on grade is bounded by engine output — at altitude, on grade, with a loaded trailer, he is near his limit on passing opportunities.

6b. Grade Energy — The Cancellation Argument

A common concern about EV architecture on mountain grades is battery depletion on the climb. The correct analysis accounts for the full round trip: grade energy largely cancels. The vehicle starts and ends at the same altitude. Energy consumed climbing is substantially recovered descending through regenerative braking. The grade is not an additive energy penalty over the round trip — it is a timing problem within the trip.

What remains after grade cancellation is aerodynamic drag — and drag is directionally invariant. A loaded equipment trailer with Cd ~0.70-0.80 is pushing air on the climb and pushing air on the descent. Regen captures braking energy on the descent but trailer drag continues working against recovery. The correct simplified model: treat the Chelan run as a long flat trip at highway speed with Cd ~0.70, not as a mountain penalty problem.

6c. Consumption Estimate Under Load

Scaling from nominal 0.357 kWh/mile at Cd ~0.40 to Cd ~0.70 under loaded trailer conditions, with rolling resistance added: realistic consumption estimate is approximately 0.50-0.55 kWh/mile sustained. This is consistent with Larry's 10 MPG loaded figure scaled to electrical equivalent — the physics is the same regardless of powertrain.

At 0.52 kWh/mile: LFP range before gen-set threshold approximately 125 miles. Gen-set sustain requirement is elevated but the mid-trip stop — which already exists in the mission profile — restores both energy stores.

6d. Two-Source Advantage at Mid-Trip Stop

Larry required a fuel stop on the Chelan run. That stop already exists in the mission plan. The Terra's mid-trip stop is structurally identical in duration — the downtime at the destination absorbs charging time without adding trip duration. The difference is capability at that stop:

Vehicle	Mid-Trip Energy Options	Depart Posture
Larry (F-150 V8)	Gasoline only — one source, market price, no flexibility	Full tank, fixed energy ceiling
Terra (EREV)	Grid charge + fuel fill — two sources, optimize between them	Full battery + full tank, maximum range posture

The Terra departs the mid-trip stop with both stores full. Larry departs with one store full. On the loaded return leg with the rollover plow, the Terra has more total energy available and more instantaneous power available than Larry at any point on the return grade.

6e. Speed Discipline

At 75 MPH with Cd ~0.70-0.80 the drag penalty is severe regardless of powertrain. The drag equation is Cd x A x v-squared — velocity squared means speed discipline matters more than powertrain selection on a high-drag trailer run. The correct speed with a loaded equipment trailer is 60-65 MPH. This applies equally to Larry and the Terra. The Terra does not change the physics; it changes the energy architecture available to manage within those physics.

7. Aircraft Engine Analogy

Lycoming O-320 class engines — 150 HP, direct drive, fixed pitch propeller, naturally aspirated — operate at approximately 48 HP/liter with TBOs of 2,000 hours. The design philosophy is fixed operating point, conservative stress fraction (65-75% of rated output at cruise), simple breathing optimized for that point, and long service life as the primary objective.

The Scout gen-set application shares this philosophy. Fixed RPM, single operating point, no broad-band torque requirement, no transmission load. A 1.5L four-cylinder running at 50-60% of its rated output at a fixed efficient RPM point is a low-stress, long-service-life application. The kit airplane analogy applies to the broader evaluation: the engineering work is Scout's job. The farm truck requirement is operational readiness on a cold November morning, not the satisfaction of solving the engineering problem.

8. Risk Register — Gen-Set Subsystem

Risk Domain	Status	Basis
Gen-set architecture complexity	Retired	Non-serialized DC bus; gen-set failure degrades to BEV, does not strand vehicle
Engine execution risk	Retired	EA211/EA888 sourced from Silao; 430,000 units/year; 12 years operational history
Supplier qualification ramp	Retired	VW Group internal supply; existing facility; not a new supplier relationship
Gen-set design maturity	Retired	Patent filing with reference-number dimensional drawings; 50-degree tilt is committed packaging solution
Thermal efficiency achievability	Retired	Single-point optimization is less demanding than propulsion tune; 36-38% is conservative
Power adequacy for cruise	Retired	40-45 HP sustained requirement; 90-100 HP available; substantial control margin
Power adequacy for high-demand mission	Retired	Battery burst source covers peak demand; gen-set sustains base load; architecture handles Chelan class run
Fuel tank packaging	Retired	10-12 gallon requirement; small, rear-of-frame compatible
SOC management for high-demand segments	Retired	Hold mode precedent established (Volt); series EREV control loop supports user-commanded SOC target natively

No gen-set subsystem risks remain open. All architecture, execution, and performance risks are retired by combination of engineering analysis, patent evidence, confirmed sourcing, production facility data, and high-demand mission analysis.

9. LFP vs NMC — Chemistry Selection Rationale

Parameter	NMC (BEV option)	LFP (Harvester option)
Pack capacity	120-130 kWh	60-70 kWh
Usable at full depth	~96 kWh (hold to 80% max)	65 kWh (full depth acceptable)
Full cycle life	1,000-1,200 cycles	2,000-3,000+ cycles
Thermal runaway risk	Present	Substantially lower
Energy density	Higher (~250 Wh/kg)	Lower (~160 Wh/kg)
Farm use fit	Chemistry penalizes daily full-depth use	Optimized for daily full-depth cycling

For a farm vehicle with a home charger doing mixed daily duty over a 10-15 year ownership horizon, LFP cycle durability is the correct chemistry selection. The gen-set extends range beyond what the LFP pack alone provides, making the capacity delta relative to NMC operationally irrelevant for the Shilofarm use case. The NMC pack's 96 kWh effective usable capacity advantage disappears against LFP's unlimited full-depth cycling over a 15-year ownership horizon.

Working Conclusion: The Scout Harvester gen-set is a well-engineered, conservatively sized, and thoroughly sourced system. The engine is a proven VW Group platform from a high-volume existing facility. The power envelope analysis confirms the gen-set is lightly loaded at sustained cruise with substantial margin for battery recovery. The dual-role architecture — gen-set as sustained energy source, battery as high-power burst source — covers the full mission envelope including the Chelan class high-demand run. The fuel requirement is smaller than intuition suggests — 10-12 gallons for 500-mile range. SOC hold mode provides strategic battery reserve management for known high-demand segments. LFP chemistry is correct for the farm use case. All gen-set subsystem risks are retired. The remaining open risks on the Terra evaluation are process risks only: EPA/CARB EREV certification, early-line production variance, and Deb ergonomic qualification at Stage 2.